ANALYSIS OF DOCUMENTS OF THE EUROPEAN COMMISSION AND THE EUROPEAN PARLAMENT REGARDING THE EUROPEAN COMMISSION´S PROPOSAL FOR A

"DIRECTIVE ON SOIL MONITORING AND RESILIENCE"

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1. BACKGROUND & OBJECTIVE

As of July 5, 2023, the European Commission has launched a proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Soil Monitoring and Resilience (Soil Monitoring Law).

The author of this report has provided a first analysis of this proposal in a previous commentary (Wenzel, 2023).

Meanwhile, the Council of the European Union has issued a paper dated November 7, 2023, summarizing the European Commission´s replies to comments and questions of the member states provided orally during the Working Party of Environment (WPE) on October 6, 2023 (Council of the European Union, 2023).

Moreover, the European Parliament has released a Draft Report on the directive proposal for a legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023). This document suggests detailed changes to the Commission´s directive proposal.

In view of a WPE meeting scheduled for November 16, 2023, the Council of the European Union has issued a Steering Note, dated November 8, 2023, providing a structure for the discussions along four clusters of the provisions of the Soil Monitoring Law (Council of the European Union, 2023).

The objective of this report is to provide an in-depth analysis of the proposal of the soil monitoring directive and the above-mentioned related documents from a soil-scientists´ view along the structure taken from the European Council´s document as shown below:

Theme	Articles	Recitals
CLUSTER 1 (Chapter I)		
Objective and Subject matter	1	1 to 23, 47, 54
Scope	2	
Definitions *(related to Chapter I)*	3 (1) (2)(3)(4)(5)(8)(10)(12)(13)((20)	
Soil districts	4	24
Competent authorities	5	25
CLUSTER 2 (Chapter II)		
Definitions *(related to Chapter II)*	3 (9) (11) (14)(15)(16)(17)(18)(21)(24)	
Soil health and land take monitoring framework	6	30, 32, 33, 34, 35
Soil descriptors, criteria for healthy soil condition, and land take and soil sealing indicators (+ Annex I)	7	26, 27,29
Measurements and methodologies (+ Annex II)	8	27, 31
Assessment of the soil health	9	28, 29
CLUSTER 3 (Chapter IV)		
Definitions *(related to Chapter IV)*	3 (9)(10) (19)(21)(23)(24)(26)	
Risk-based approach	12	43, 46
Identification of potentially contaminated sites	13	43, 44
Investigation of potentially contaminated sites	14	43, 45
Risk assessment and management of contaminated sites (+Annex V & VI)	15	43, 46
Register (+Annex VII)	16	43, 48
CLUSTER 4 (Chapters III & V)		
Definitions *(related to Chapters III & V))*	3(5)(6)(7)(19)(22)(25)	
Sustainable soil management (+Annex III & IV)	10	37 38 39 40 41 42
Land take mitigation principles	11	30
Union financing	17	11
Reporting by Member States	18	52
Information to the public	19	36
Exercise of Delegation	20	51
Committee	21	52
Access to justice	22	49
Penalties	23	
Evaluation and review	24	23 53
Transposition	25	55
Entry into force	26	

2. CLUSTER 1 (CHAPTER I)

2.1 OBJECTIVE & SUBJECT MATTER (Article 1)

My comments:

In **Article 1** (Objectives and Subject Matter), the objective of the Directive is defined as *"…to put in place a solid and coherent soil monitoring framework for all soils across the EU and to continuously improve soil health in the Union with the view to achieve healthy soils by 2050 and maintain soils in healthy condition…"*. In Article 9, it is defined that a "Soil is healthy if it meets the criteria for healthy soil for **all** soil descriptors listed in parts A and B of Annex I."

Combining the above cited statements in Article 1 and Article 2 leads to the conclusion that all European soils are required to achieve the thresholds of all criteria of healthy soils by 2050. If we accept the statement in paragraph (2) of the introductory section that "60 – 70% of the European soils are deteriorated", the objective is unrealistic. It is even hard to imagine that all European soils will achieve all criteria of soil health at any time. To give an example, I doubt that the erosion rates in all cultivated and vineyard soils in Europe can be brought down to < 2 t ha^{-1} yr^{-1} by 2050, if at all, especially if no principal changes regarding land use (e.g., shifting diets) are implemented.

It remains unclear what happens if a member state will not achieve the objective. While individual member states have to implement a penalty system for actors that violate the directive, I could not find any sanctions for EU member states that do not achieve the objectives or convey to the responsibilities set by the directive. It is difficult to identify the link between the directive´s objectives and requirements, and the action of individual stakeholders.

Article 1 defines that "*The objective of the Directive is to put in place a solid and coherent soil monitoring framework for all soils across the EU and to continuously improve soil health in the Union with the view to achieve healthy soils by 2050 and maintain soils in healthy condition, …*". Note the sequence of the main objectives, with monitoring mentioned before the objective to improve soil health. Monitoring is important but only one of the tools to support EU soil health policies. Accordingly, the current version gives the wrong signal to stakeholders and actors.

In my view, the main objective should be the improvement of soil health in the EU, along with ambitious but realistic targets (based on the descriptors, thresholds and criteria). As also indicated in my comment on the general objectives, there is a gap between the general objective and the monitoring activities and related reporting. What is the roadway to the objective targeted by 2050 (i.e., all soils should be healthy regarding all criteria)? I am missing operational, realistic targets along a timeline, and related plans and consequences if those targets are not achieved.

Overall, I conclude that, while the objective is too ambitious, the consequences for member states that do not comply to the objectives are not defined, and the focus of the main text is biased towards monitoring.

Selected replies of the European Commission to questions of member states (November 7, 2023):

- This objective is not too ambitious compared with the legally binding provisions of the SML. The proposal reflects a staged approach (deliberate, due to the knowledge limitations and lack

of sufficiently granular data) and this is one of the reasons why an early evaluation of the directive is foreseen after 6 years.

Comment on this reply:

Even if the objective is not binding, it is not realistic in relation to other provisions and definitions of the proposal for a directive on soil monitoring and resilience. Given the provisions in Article 9, which defines that a "Soil is healthy if it meets the criteria for healthy soil for **all** soil descriptors listed in parts A and B of Annex I.", this objective cannot be achieved. I agree to set ambitious objectives but it not useful to define targets that can never be achieved. The problem is further elucidated by the Commission´s reply to the following question of several member states:

"Why descriptors and criteria do not change with land use? (AT, BE, CZ, DE, DK, FI, SI)"

The Commission´s response "Descriptors and criteria do not generally depend on land use because they are intended to identify a critical loss of ecosystem services, irrespective of the land use. This is consistent with the overall SML approach (see art 1: objective)" reinforces my view that the objectives of the SML are not realistic. Identification of losses of ecosystem services relative to other land use systems or even unmanaged soils is of scientific interest but should not be confused with the legislative objective to improve soil health. There is overwhelming evidence that realistic targets for, e.g., soil erosion or soil organic carbon levels will depend on the major land use regime. If we want to produce sufficient food, it is not realistic to turn cultivated soils into grasslands or natural vegetation at large scale.

Amendment 25 of the legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023):

Amendment 25 is adding the following sentence to **Paragraph 1, Article 25** of the SML proposal:

"This Directive therefore establishes a framework within which Member States are required to put in place measures to ensure that by 2050 all soils are in a healthy condition."

Comment:

Amendment 25 requires member states to ensure that by 2050 all soils are in healthy conditions. This goes clearly beyond the requirements of the SML proposal and is in contrast to the European Commission´s reply to related questions of the member states (see above). Given the unrealistic approach of requiring a "healthy soil" to meet the health criteria of all soil descriptors, and the premature nature of their assessment and criteria definition, this would result in an unpredictable burden and legal risk for the Member States and all other stakeholders (e.g., land owners) involved.

2.2 SCOPE (Article 2)

I agree that all soils in Europe should be covered by the directive.

2.3 DEFINITIONS RELATED TO CHAPTER I (Article 3)

Amendment 28 of the legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023):

Amendment 28 introduces a **new paragraph 1a to Article 3** for defining a graded approach to soil health assessment, with the intention to replace the binary ("heathy" versus "unhealthy") soil health classification system of the SML proposal:

"(1a) 'soil ecological status' means the ecological quality of a soil evaluated according to the soil's diversity, biological and functional activity, habitat and the presence of degradation factors and determined according to the following classification:

(a) 'high soil ecological status' for soils with high biological and functional activity and structure; (b) 'good soil ecological status' for soils in an overall good ecological status but that show evidence of slight adverse impacts from one or multiple degradation factor;

(c) 'moderate soil ecological status' for soils with evidence of slight adverse impacts from one or multiple degradation factors;

(d) 'degraded soils' for soils with clear evidence of adverse impacts from one degradation factor; and

(e) 'critically degraded soils' for soils with clear evidence of adverse impacts from more than one degradation factor.

Comment:

I welcome this modification for defining a more graded soil health assessment scheme that differentiates between several soil health categories. Applicability, however, will largely depend on realistic and applicable thresholds (criteria) for separating the soil health categories for each soil health descriptor. Moreover, the approach should be refined to allow for more flexibility, i.e., I propose to allow for 2 to 5 categories, depending on the available assessment schemes for a given soil health descriptor. For instance, published categorization of soil health in relation to SOC:clay ratios are using 4 categories, some schemes to assess nutrient (e.g., P) availability 5 categories, whereas in other cases it may be more appropriate to distinguish only 3 categories, and in the case of soil sealing it may be enough to distinguish "sealed" versus "non-sealed".

Paragraph 5 of the definitions related to Chapter I requires some reflection in relation to the ambitious objectives of the SML proposal:

"(5) 'sustainable soil management' means soil management practices that maintain or enhance the ecosystem services provided by the soil without impairing the functions enabling those services, or being detrimental to other properties of the environment"

Comment:

The SML falls short in depicting the major leverages for restoring soil health in Europe by implicitly limiting the definition of "sustainable soil management" to individual management practices. The agri-environmental programmes funded under the umbrella of the CAP has resulted in some improvements of soil health by employing more sustainable management practices. However, doing more of the same

will not ensure sufficient progress in restoring soil health. It requires European policies and programmes that go far beyond the current agri-environmental policies by reducing the area required for agricultural production. This can be efficiently done by serious efforts to reduce food waste and shifting the food system significantly towards more plan-based diets. This should be acknowledged in the definitions and in Chapter III (Sustainable Soil Management Options).

2.4 SOIL DISTRICTS (Article 4)

The concept of soil districts as such is reasonable.

However, **Article 4, Paragraph 2** requires the member states to define the geographical extent of soil districts by seeking homogeneity of the soil district in terms of the following parameters:

"When establishing the geographic extent of soil districts, Member States may take into account existing administrative units and shall seek homogeneity within each soil district regarding the following parameters:

- (a) soil type as defined in the World Reference Base for Soil Resources;
- (b) climatic conditions;
- (c) environmental zone as described in Alterra Report 2281[75];
- (d) land use or land cover as used in the Land Use/Cover Area frame statistical Survey (LUCAS) programme."

Comment:

Homogeneity regarding soil type, climatic conditions and environmental zone as wells land use / land cover class is not at all realistic at the level of NUTS 1 level, which is the minimum requirement in terms of the number of soil districts in the member states as defined in the SML proposal. NUTS 1 units typically comprise various climatic and ecological zones, and a multitude of soil groups according to the World Reference Base for Soil Resources (WRB) or soil types of the respective national soil classification systems. It is inappropriate to set requirements in different parts of the SML that do not comply with each other.

Moreover, the homogeneity requirements of Article 4 even cannot be satisfied if soil districts are defined as reasonably-sized subunits of NUTS 1. It is normal to find different land uses not only within NUTS 1 level but down to the landscape level. Equally, it is almost impossible to find landscapes that show uniform soil type. The requirement could be changed to "soil type pattern", i.e., a mosaic of different soil types typical for the region and its environmental / climate conditions. Equally, I think that soil districts may have typical soil use pattern rather than uniform soil use. However, at NUTS 1 level even this modified approach may be difficult to achieve; this is more likely at the level of the small production regions (e.g., small agri-environmental regions or "Kleinproduktionsgebiete" as defined in Austria). However, by defining smaller soil districts below NUTS 1 level, the number of sampling sites will increase in accordance with provisions laid down in Part A of Annex II that require the member states to determine the sample size "*by applying the Bethel algorithm (Bethel, 1989)*" to obtain "*a maximum percent error (or Coefficient of Variation) of 5% for the estimation of the area having healthy soils*" (Part A of Annex II).

Note that the term “soil type” used in paragraph (1) of Article 4 is incorrect for soil units of the World Reference Base for Soil Resources. The correct term is “soil group”. This should be corrected.

The reference made to the “environmental zones as described in Alterra Report 228175” is not relevant considering the different scales of the envisaged soil districts (relatively small areas) and the environmental zones defined in the Alterra Report.

The exclusive reference made to the Land Use/Cover Area frame statistical Survey (LUCAS) programme is ignoring other, possibly more appropriate databases such as INVECOS or other national data. I think this reference should be deleted.

Article 4 should therefore be rewritten by setting realistic criteria for the selection of soil districts in relation to the chosen scale (NUTS 1 level and below), and avoid indirect and non-transparent implications for other aspects of the SML, such as the one exemplified above. Moreover, it should not ignore existing information and methodologies. I suggest that **Article 4** could be amended as follows:

“Soil districts

1. Member States shall establish soil districts throughout their territory. The number of soil districts for each Member State shall as a minimum correspond to the number of NUTS 1 territorial units established under Regulation (EC) No 1059/2003.

2. When establishing the geographic extent of soil districts below the NUTS 1 level, Member States may take into account existing administrative units and shall seek to obtain relatively uniform conditions within each soil district regarding the following characteristics:

(a) pattern of soil groups as defined in the World Reference Base for Soil Resources[74];

(b) prevailing climatic conditions;

(c) pattern of land use or land cover.”

Amendment 37 of the legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023):

Amendment 37 replaces the term “seeking” by “prioritise” in **Article 4, Paragraph 2** of the SML proposal:

“When establishing the geographic extent of soil districts, Member States may take into account existing administrative units and shall prioritise homogeneity within each soil district regarding the following parameters:”

Comment:

The intention of this change remains unclear. The legislative meaning of both terms, i.e., “seeking” and “prioritise” is ill-defined. Moreover, none the two versions resolved the problems of Article 4, Paragraph 2 as discussed above.

2.5 COMPENTENT AUTHORITIES (Article 5)

No comment.

3. CLUSTER 2 (CHAPTER II)

3.1 DEFINITIONS RELATED TO CHAPTER II

No comment on the SML proposal.

However, the changes to definitions suggested by the legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023) may require a detailed analysis which was not possible within the time available.

3.2 SOIL HEALTH & LAND TAKE MONITORING FRAMEWORK (Article 6)

In **Article 6, Paragraph 4**, the SML proposal requires that "The Commission shall, subject to agreement from Member States concerned, carry out regular soil measurements on soil samples taken in-situ, based on the relevant descriptors and methodologies referred to in Articles 7 and 8, to support Member States' monitoring of soil health. Where a Member State provides agreement in accordance with this paragraph, it shall ensure that the Commission can carry out such in-situ soil sampling."

Amendment 42 of the legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023):

Amendment 42 changes **Paragraph 4, Article 6** to:

"The Commission shall, in cooperation with Member States, carry out regular soil measurements on soil samples taken in-situ at least every three years, based on the relevant descriptors and methodologies referred to in Articles 7 and 8, to support Member States' monitoring of soil health. Member States shall provide the necessary authorisation and support to the Commission in order to ensure that the Commission can carry out such in-situ soil sampling."

Comment:

This change weakens the position of the Member States considerably, and, at least theoretically, would allow the Commission to establish soil monitoring without the consent of the Member State. I strongly

suggest to give priority to the existing monitoring programmes of the member states that, if required / desired, can allow for additional sampling by the Commission.

The justification for this change advocates that "Engagement between the Commission (JRC and LUCAS soil) and the Member States to the take samples in different countries would promote training and capacity building when needed in each country. Member States will by involving relevant authorities and research institutions take full advantage of existing programs and local knowledge and improve the link between national and EU monitoring projects."

In my view, many of the monitoring programmes in the Member States are more advanced and reliable than the LUCAS programme run by the Commission.

The SML proposal urges the member states to include LUCAS points (≥20%) in their soil health monitoring network. However, there is no evidence provided as to whether the LUCAS sampling is suited to be included in terms of differences in sampling procedures, sampling depths, time of sampling etc. Moreover, the quality of LUCAS data may not be comparable to that of national authorities, as the most crucial aspect, i.e., soil sampling is outsourced to private companies with limited expertise in soil science, which in turn hire helpers with no or little training. Using LUCAS points may be useful in member states with limited monitoring activities but are likely to complicate data analysis and affect data quality in countries like Austria that could still include these data on a voluntary basis.

3.3 SOIL DESCRIPTORS, CRITERIA FOR HEALTHY SOIL CONDITIONS, AND LAND TAKE AND SOIL SEALING INDICATORS (Article 7 including Annex I)

Article 7 makes reference to the soil descriptors and soil health criteria to be employed as listed in Annex I.

Comment:

The references made to Annex I as such are no problem, however, as detailed in my comments below, the content of Annex I is premature, incomplete, and partly not in line with scientific standards and state-of-the art.

Amendment 46 of the legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023):

Amendment 46 suggests to change the **heading of Article 7** from:

"Soil descriptors, criteria for healthy soil condition, and land take and soil sealing indicators"

to:

"Soil descriptors, criteria for soil ecological status, land take and soil sealing indicators"

Comment:

I agree that the title requires some modification to account for the grades soil health assessment scheme proposed in amendment XX. However, I cannot see any advantage to replace the term "healthy" by "ecological" unless the change in terminology is applied throughout, and the meaning can be considered identical. Therefore, I suggest to replace the term "soil ecological status by "soil health status".

3.4 MEASUREMENTS & METHODOLOGIES (Article 8 including Annex II)

Paragraph 1 of **Article 8** requires that the "Member States shall determine sampling points by applying the methodology set out in part A of Annex II."

Comment:

This article along with the details laid down in part A of Annex 2 introduces a mandatory methodology for selecting sampling points, requiring member states to apply "*stratified sampling optimized on the soil health descriptors*", "*taking into account LUCAS Soil measurements*", and determining the sample size "*by applying the Bethel algorithm (Bethel, 1989)*" to obtain "*a maximum percent error (or Coefficient of Variation) of 5% for the estimation of the area having healthy soils*". The directive proposal does not provide any guidance how this could be done but refers only to the original article of Bethel which has no link to soil surveys. This should be clarified by, e.g., making reference to Ballin et al. (2022) where the use of the Bethel algorithm is demonstrated for the LUCAS sampling schemes. However, it still remains unclear if and how the location of the sampling points selected by the Bethel / LUCAS methodology would integrate the sampling sites of the existing soil monitoring programmes of the member states. It should be clarified in the SML that member states in the first place shall continue their existing monitoring. Using the Bethel algorithm, sampling sites required by the SML shall be selected using the Bethel-algorithm-based LUCAS scheme. And if needed, additional sampling sites can be selected using the same approach.

Given that the majority of member states has been conducting soil monitoring for decades, it is not proportionate to introduce a new sampling scheme without explicitly considering existing programmes. There is a risk that the current SML proposal will result in additional costs that are not required to achieve the objectives of the directive. Many national monitoring systems follow a regular grid, some with a high density of sampling points. In Austria, the sampling grids for grassland and cultivated soils are 3.89 x 3.89 km for sampling down to 70 cm depth, and 2.75 x 2.75 km for topsoils. In terms of costs, given this high density of sampling locations, it is inevitable to avoid repeated sampling (soil monitoring) on sites that are determined by different methodology. To this end, the SML should provide clear provisions, by introducing the methodology starting from existing monitoring programmes of the member states.

The directive proposal does not specify if only topsoils or also subsoils should be sampled, and to which depth. Given that detectable changes are typically limited to topsoils, we suggest to include subsoils only in the initial sampling, and to concentrate on topsoils in subsequent samplings to ensure that the effort and costs for monitoring are proportional. If subsoils data are available from national monitoring programmes, these data may be used. This should be clarified in the SML. Moreover, the SML should allow for a reasonable range of topsoil depths, i.e., between 15 and 30 cm, to allow for continuation of

national monitoring using the existing methodology. The results can be easily recalculated for other reference depths using, e.g., spline functions, to obtain a harmonised European dataset.

Paragraph 2, Article 8 of the SML requires that:

"Member States shall carry out soil measurements by taking soil samples at the sampling points referred to in paragraph 1 and collect, process and analyse data in order to determine the following:

(a) the values of the soil descriptors as set in Annex I;

(b) where relevant, the values of the additional soil descriptors;

(c) the values of the land take and soil sealing indicators listed in part D of Annex I."

Comments:

Annex 1 should be reformatted to show clearly which parts belong to part A or B.

In the following I comment on individual aspects of **Annex I**:

The soil health criteria set for soil salinization (electrical conductivity < 4 dS m^{-1}) are reasonable. However, it is not applicable if no reference soil depth is specified.

Setting the soil health criteria for soil erosion to ≤2 to t ha^{-1} seems unrealistic in view of the measures proposed in Annex IV in relation to Article 10. The European Commission justified this threshold in response to comments from the member states (European Commission, 2023) as follows:

"The rate is based on scientific evidence which sets the soil formation yearly rate at 1.4 tons per hectare per year (EEA, Soil monitoring in Europe – Indicators and thresholds for soil health assessments; "Verheijen et al. (2009) used European data on soil formation to calculate a tolerable soil loss for Europe of 0.3 - 1.4t/ha/year)"

I agree that keeping the erosion rates below soil formation rates would indeed be sustainable and therefore desirable, it can be hardly achieved in many cultivated soils, especially if placed in hilly regions, without major land use change. Moreover, the threshold does not account for eroded soil material deposited with landscapes (colluvial soils), often generating enhanced ecosystem services (e.g., soil organic matter preservation, enhanced water holding capacities) at the colluvial sites.

Using the SOC/clay ratio to define soil health criteria for mineral soils is likely superior to basing it on SOC concentrations only. However, it is not applicable if no reference soil depth is specified. I assume that the proposed SOC/clay ratio of <1/13 to define unhealthy soils refers to mineral topsoils. Note that the threshold is based on very limited evidence from two European regions, one considering only Luvisols in Western Switzerland (Johannes et al., 2017), the other one covering different soil groups across England and Wales (Prout et al., 2021). This is not representative for the variation of climates, soils and environmental zones across Europe. The work of Johannes et al. (2017) refers to a soil depth of 5 – 10 cm, that of Prout et al. (2021) to a depth of 0-15 cm. This needs to be considered when adopting their 1/13 SOC:clay ratio threshold for separating "healthy" and "unhealthy" soils. Where

ever soil sampling follows deviating depth increments, data need to be normalised to the specified depth. Note that this applies in particular also to the LUCAS soil sampling depth of 0 – 30 cm.

The option to adjust the soil health criteria (i.e., the SOC/clay ratio of 1/13) by employing corrective factors for climate conditions is as such reasonable, however, it is not clear how the SOC levels in grassland soils should be taken into account. Another problem arises in regions where virtually no grassland soils are available, such as in the main production areas (argi-ecological regions) in the lowlands of eastern Austria (Nordöstliches Flach- und Hügelland, eastern parts of Alpenvorland). In line with general considerations (see my comments in 2.1), the definition of thresholds should consider differences between major land use categories. It has been advocated (Rosinger et al., 2023) and shown (Wenzel et al., 2022) that using, e.g., the top 10% of SOC concentrations within a land use category might provide a more reasonable target for soil health restoration. Similarly, a lower limit separating "healthy" and "unhealthy" soils could potentially be derived for each land use category and region. It has been also shown that even the best "pioneer" farming systems were still far from attaining SOC stocks of nearby reference systems (grassland strips and hedgerows) even after on average 26 years of operation (Rosinger et al., 2023).

Emerging evidence questioning the suitability of SOC:clay ratios as a reliable measure of the SOC status of soils has become available in recent years. Rasmussen et al. (2018) identified, depending on soil pH, oxyhydroxides of Al and Fe and exchangeable Ca as predictors of soil organic carbon, outperforming clay contents. Similarly, Bösch et al. (2023) and Wenzel et al. (2023) were able to identify amorphous oxyhydroxides of Al as key variable controlling soil organic carbon levels in forest, hedgerow and cultivated soils at regional scale, whereas SOC was not related to clay content. Moreover, even within the same land use category, SOC:clay ratios vary considerably among neighbouring ecological regions with different climate and parent materials across the province of Lower Austria, and are not related to soil structural quality scores as would be expected from the work of Johannes et al. (2017) and Prout et al. (2021) (unpublished own data; report / publication in preparation).

Overall, it is concluded that setting a general threshold for SOC:clay ratios for separating "healthy" from "unhealthy" soils across Europe and for all land use categories is not supported by scientific evidence. I suggest to allow the member states to define thresholds for each soil district and land use category and to develop a methodology for identifying the threshold that ideally could be applied to all regions.

For soil contamination, there is no specification whether total or labile metals shall be determined. What is the meaning of "*reasonable assurance that no unacceptable risk for human health and the environment exists form soil contamination*"? I think it is possible to determine, at least on national level, criteria for healthy soils using available (sometimes even legally binding) norms, legislation and related scientific literature. For instance, we could use the concept of background / reference values (healthy soils), tolerated values (increased risk) and remediation values (unhealthy soil).

The definition of the degradation aspect "reduction of soil capacity to retain water" lacks clarity in several aspects. The related soil descriptor, "water holding capacity" is defined as "% of volume of water / volume of saturated soil". I think that it should be the % of water content / total volume of soil at saturation? The related criteria for soil health condition are defined as "*The estimated value for the total water holding capacity of a soil district by river basin or subbasin is above a minimum threshold. The minimal threshold is set (in tonnes) by the Member State at soil district and river basin or subbasin level to mitigate the impacts of floodings following intense rain events or of periods of low soil moisture due to drought events.*". I have no clue how such an imprecise definition can be implemented, and how

soil health can be determined on that basis. How do we come up with the "minimum threshold", what are the procedures / criteria to determine it? As there is no specification of depth to which the water holding capacity has to be calculated, the definition is not applicable. Moreover, the minimum threshold is not defined for the individual soils at the sampling points but at soil district and river basin level, requiring additional data and interpolation. This approach is also inconsistent with all other parts of the directive, as it would not allow to determine the area of healthy soil, having only on value for a soil district or its river basins.

I suggest to replace this approach by a simple indicator, i.e., percentage (volume/volume) of water holding capacity (or field capacity) in the topsoil, and if available in other soil layers, specified to the selected reference depth (e.g., from 0 - 30 cm). Using this alternative approach, the data could be treated in the same way as for all other descriptors by identifying the proportion of healthy and unhealthy soils in a given soil district.

Generally, it is unclear how land take / soil sealing is considered in the calculation of the proportion of healthy soils in a soil district. In the current draft of the directive proposal, areas of sealed soil / land take are not excluded from the objective to make sure that all European soils are healthy in terms of all soil health criteria by 2050.

For the aspect of subsoil compaction, the directive proposal requires bulk density measurements in "*subsoils (B horizon)*". Mentioning B horizons is inappropriate as many soils do not have B horizons, e.g., most Chernozems and Phaeozems, Leptosols, Fluvisols, Gleysols, Stagnosols etc. The depth of subsoils that should be ideally sampled should be defined. The effort of repeated, volumetric subsoil sampling with sufficient replicates would be enormous, therefore the possibility of using a pedotransfer function is appreciated. However, the method referred to in the directive (Hollis et al., 2012, European Journal of Soil Science 63, 96 – 109) has not yet been validated for some important soil groups, including Chernozems and Phaeozems that are important in the eastern parts of Austria. The criteria for soil health in relation to subsoil compaction are differentiated for soil textural classes for which the directive refers to SSSA methodology. Why not referring to the definition provided by FAO which would be consistent with the use of the international guidelines for soil description and related classification of soil groups using the World Reference Base for Soil Resources as common in the EU? Note that, while the texture triangles are identical for USDA (SSSA) and FAO guidelines, this does not apply for the underlying diameter limits of sand, silt and clay particles! Accordingly, particle size measurements following ISO norms as required by the directive would not be directly applicable in this context.

The aspect of soil degradation "excess nutrient content in soil" should be more accurately termed "*excess nutrient concentration in soil*". The range of "*maximum value*" for available P to be laid down by the member states (30 – 50 mg kg^{-1}) refers to the Olsen method, which is fine if used as a reference. However, I do not understand why it is a range and not a value, as this will affect the proportion of "healthy soils" which value is chosen by a member state. What are the considerations behind defining a range, given that this range refers to the same method? Here again, there is no specification of the soil depth to which the "maximum value" applies.

Why there are no soil health criteria provided for compaction of topsoils? I think they could be defined for the different land use categories. Plow pans may be critical limitations for plant root growth and

exploration of the soil volumes for water and nutrients, and for soil water infiltration and subsequent storage. This should be addressed somehow by the directive.

The degradation aspect "*Loss of soil biodiversity*" should be renamed to "Loss of soil biological integrity", as this is more comprehensive (including different aspects of biodiversity and ecosystem functioning) and would better reflect the indicative list of related soil descriptors. For instance, potential soil basal respiration or microbial biomass cannot be considered as biodiversity but rather integrity characteristics. As the selection of descriptors for soil biological integrity is largely left to the member states, and monitoring of a large number of sites may be costly, I suggest to (alternatively) use known relations between soil characteristics such as soil organic carbon and microbial parameters to assess and monitor the soil biological integrity at least roughly. Such relations could be validated on smaller sample numbers in each soil district. What is the rationale for selecting potential soil basal respiration as the only mandatory descriptor for soil biological integrity? To my knowledge, substrate-induced respiration is frequently used, and, for instance, it has been measured in some soil inventories in Austria.

Amendment 123 of the legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023):

In **Amendment 123**, various changes to **Annex I** of the SML proposal are suggested. Three levels of soil monitoring and assessment schemes (Tiers 1, 2 and 3) are defined, building on each other, for which the Member States can opt. It remains unclear, if, at some point, Member States would be forced for an upgrade of their selected Tier. More time would be required for a detailed analysis of the changes and their legal consequences for the Member States.

Paragraph 3, Article 8 requires that:

"Member States shall apply the following:

(a) the methodologies for determining or estimating the values of the soil descriptors set out in part B of Annex II;

(b) the minimum methodological criteria for determining the values of the land take and soil sealing indicators set out in part C of Annex II;

(c) any requirements laid down by the Commission in accordance with paragraph 6.

Member States may apply other methodologies than the ones listed in the first subparagraph, points (a) and (b), provided that validated transfer functions are available, as required in Annex II, part B, fourth column."

Comments:

Saturated soil paste extract as first choice for determining electrical conductivity is not considering the large amount of soil required, and the related work load and costs involved. I therefore suggest to use an aqueous soil extract as defined in ISO 11265:1994 as first option.

The methodology described for assessing soil erosion is vague. Why not explicitly referring to the Universal Soil Loss Equation (USLE)? It remains also unclear how the assessment of soil erosion is linked with the monitoring of other soil descriptors. It is hard to imagine that erosion measurements are conducted at the monitoring sites selected according to Paragraph 1 of Article 8. I assume that modelling as it is already performed to evaluate the success of the agri-environmental programmes in Europe is the method of choice, accompanied by a reasonable number of field monitoring / experimental sites. All this should be clearly described / defined in the SML.

I do not understand why "potential environmental available content of heavy metals in soils based on ISO 17586:2016 using dilute nitric acid" is selected as standard method for metal pollutants. The most common and more reasonable approach is to determine (near total) metal and metalloid concentrations, e.g., using aqua regia or other strong acids yielding similar results. Results obtained by such digestion methods would (1) be more suitable to quantitatively detect accumulations or losses of metals / metalloids in soils, and (2) be in line with norms and legislation for the assessment of soil pollution in most member states.

Amendment 55 of the legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023):

Amendment 55 is adding a second option to the last sentence of **Paragraph 3, Article 8**:

"Member States may apply other methodologies than the ones listed in the first subparagraph, points (a) and (b), provided that validated transfer functions are available or may be estimated by comparing data taken at Member State level with in-situ monitoring coordinated by the Commission, as required in Annex II, part B, fourth column."

Comment:

I have no clue how a simple comparison with other monitoring sites coordinated by the Commission allows for a validated conversion of data to the reference system.

Paragraph 5, Article 8 of the SML requires that the "Member States shall ensure that new soil measurements are performed at least every 5 years. Member States shall ensure that the value of the land take and soil sealing indicators are updated at least every year."

Comments:

With this provision, the directive proposal requires member states to "*ensure that soil measurements are performed at least every 5 years*". First, the wording is imprecise as I believe that this implies also that the sampling needs to be repeated at least every 5 years. If so, this should be clearly stated in the directive. Based on available literature and own monitoring activities, I doubt that a 5 years period is useful and effective, as even changes of relatively labile soil characteristics such as pH (intensity factor) and soil organic carbon are unlikely to be detectable (statistically significant) after ≤5 years, unless an unproportionally (unrealistic) large number of sampling points is available within each soil district. And even if statistically significant, it may not be relevant in terms of magnitude (Webster, 2001). The efforts and costs associated with a five-years cycle of soil sampling and measurements are not justified in view of the expected information gained. Moreover, a reasonable timeframe of replicated sampling should consider differences in the sensitivity of the soil descriptors to temporal change.

I therefore suggest to change paragraph 5 of Article 8 to:

"Member States shall ensure that soil sampling at the monitoring sites selected or established in accordance with Article 8 (1) and related measurements of soil descriptors shall be repeated at least every 10 years. Member States shall ensure that the value of the land take and soil sealing indicators are updated at least every year."

Amendment 56 of the legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023):

Amendment 56 suggests to change the subparagraph 1 of **Paragraph 5, Article 8**, from:

"Member States shall ensure that new soil measurements are performed at least every 5 years."

to:

"Member States shall ensure that new soil measurements are performed at least every 5 years. Member States shall also facilitate soil monitoring being carried out at shorter intervals to facilitate in-situ soil monitoring coordinated by the Commission."

Comment:

As I do not agree that Member States should be forced to accept conduct of the LUCAS monitoring without their agreement, I am not in favour of this amendment. In any case, it would be better to conduct replicated sampling in longer intervals (10 years), but with higher quality standards than employed in LUCAS.

3.5 ASSESSMENT OF SOIL HEALTH (Article 9 and Annex I)

Amendment 58 of the legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023):

Amendment 59 of **subparagraph 2 of Paragraph 1, Article 9** replaces:

"Member States shall also take into account the data collected in the context of soil investigations referred to in Article 14."

by:

"For the assessment of the soil ecological status, Member States shall also take into account the data collected in the context of soil investigations referred to in Article 14."

Comment:

As already outlined above, I would keep the prevailing terminology of the SML proposal, and use "soil health status" rather than "soil ecological status". This applies also in any other occasion throughout the document.

Paragraph 2 of Article 9 defines that "A soil is considered healthy in accordance with this Directive where the following cumulative conditions are fulfilled:

(a) the values for all soil descriptors listed in part A of Annex I meet the criteria laid down therein and, where applicable, adapted in accordance with Article 7;
(b) the values for all soil descriptors listed in part B of Annex I meet the criteria set in accordance with Article 7 ('healthy soil').

By way of derogation from the first subparagraph the assessment of soils within a land area listed in the fourth column of Annex I, shall not take into account the values set out in the third column for that land area.

Soil is unhealthy where at least one of the criteria referred to in subparagraph 1 is not met ('unhealthy soil')."

Comment:

The definition requiring that a "Soil is healthy if it meets the criteria for healthy soil for **all** soil descriptors listed in parts A and B of Annex I." is ignoring the reality, and will definitely not allow to achieve the overall albeit non-binding objective that all European soils should be healthy by 2050. This approach also obscures any achievement regarding soil health for the individual soil health descriptors. There is a simple solution to this issue: Soil health should be assessed and reported for each soil health descriptor individually, which is not only more informative but also more awarding for the stakeholders involved.

I therefore suggest to change **paragraph 2, Article 9** to:

"Assessment of soil health shall be conducted and reported for each soil descriptor listed in part A of Annex I and part B of Annex I individually. For a given soil health descriptor, a soil is considered unhealthy if the respective criteria are not met.

By way of derogation from the first subparagraph the assessment of soils within a land area listed in the fourth column of Annex I, shall not take into account the values set out in the third column for that land area."

Amendment 60 of the legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023):

Amendment 60 of **Paragraph 2, Article 9** suggest to change subparagraph 1 from:

"A soil is considered healthy in accordance with this Directive where the following cumulative conditions are fulfilled: A soil is considered healthy in accordance with this Directive where the soil is classified either with good or high ecological status.

(a) the values for all soil descriptors listed in part A of Annex I meet the criteria laid down therein and, where applicable, adapted in accordance with Article 7;

(b) the values for all soil descriptors listed in part B of Annex I meet the criteria set in accordance with Article 7 ('healthy soil')."

to:

"A soil is considered healthy in accordance with this Directive where the soil is classified either with good or high ecological status."

Comment:

While I agree to take the proposed gradual approach of soil health assessment by defining more than two categories where appropriate, I also suggest to keep flexibility in allowing between 2 and 5 categories, depending on the soil descriptor considered. In line with this, I would classify soils in terms of the soil health categories, without merging classes again. For instance, we could use terms such as "very good health status", "good health status", "moderate health status", "poor health status", "very poor health status", or something similar. And, as indicated above, use "soil health status" rather than "soil ecological status".

Moreover, the amendment, while aiming at introducing a gradual approach to soil health assessment, does not change the last subparagraph of Paragraph 2, Article 9:

"Soil is unhealthy where at least one of the criteria referred to in subparagraph 1 is not met ('unhealthy soil')." If a gradual approach is taken, this should also involve unhealthy soils.

In Paragraph 4 of Article 9, the SML proposal requires the member states that "Based on the assessment of soil health carried out in accordance with this Article, the competent authority shall, where relevant in coordination with local, regional, national authorities, identify, in each soil district, the areas which present unhealthy soils and inform the public in accordance with Article 19."

Comment:

This provision requires detailed consideration of the implications for the accuracy required to delineate unhealthy soils in a given soil district.

The related reply of the European Commission to questions of the member states that "Art 9.4 requires that in each district the areas with unhealthy soils need to be identified with a view to gradually implement regeneration practices. This requires spatial delineation of these areas. Only calculating a percent rate per district is not sufficient. For the information to the public, see article 19.", is not satisfying as it does not clarify the required accuracy (parcel level?) and methodologies behind.

Amendment 65 of the legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023):

In **Amendment 65**, the following new **Paragraph 4a** is added:

"4a. Soil districts shall consider establishing their soil district plans, including measures and targets to achieve measurable improvement of soil health conditions, taking into account the ecological status classification and obligations referred to in Article 7. The establishment of the soil district plans shall be the result of an inclusive process with local stakeholders. The soil district plans shall be made available online by the respective Member State."

Comment:

I fully support this approach, as it shifts the focus to defining procedures for the implementation of measures, which is more important than the SML proposal´s intention of harmonizing soil monitoring systems in Europe. The soil district´s level could also provide the scale for integrated planning and

implementation of measures beyond soil health, such as biodiversity, nature conservation, and climate change mitigation and adaptation, and water management at landscape level. However, the key for effective progress is a shift in the overall European land use policies towards reduction of food waste and more plant-based diet to reduce the intensity of land use and/or deliver areas for other purposes (ecosystem services), e.g., nature conservation and water retention.

Amendment 66 of the legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023):

In **Amendment 66**, the following new **Paragraph 4b** is added:

"4b. Member States shall ensure that the ecological status classification of soils in the respective soil districts is improved within the following periods:

(a) 10 years for critically degraded soils;

(b) 6 years for degraded or moderate ecological status soils.

By way of derogation from the first subparagraph, Member States may apply different periods for soils registered as contaminated on condition that concrete management and mitigation plans with predefined timelines and concrete targets are in place."

Comment:

The time periods allowed for improving soil health status should be based on scientific evidence, if these targets can indeed be achieved by employing the measures and plans listed in Annex III. Another fundamental requirement would be a realistic, scientifically-sound definition of the soil health criteria (see my respective comments on Chapter 3 and related Annexes below).

Moreover, it remains unclear which proportion of the soils in each category should be improved to move up into a better soil heath category within the indicated periods. Legislation should be accurate and unequivocal in order to become applicable and legally secure.

Amendment 67 of the legislative resolution, dated October 24, 2023 (European Parliament Committee on the Environment, Public health & Food Safety, 2023):

In **Amendment 67**, the following new **Paragraph 4c** is added:

"4c. The Commission shall establish, at the Union level, threshold values for all soil descriptors in Tiers 1 and 2 for soil monitoring design regarding the five-level classification of soil ecological status. When applying a Tier 2 for soil monitoring design, Member States may establish their own threshold values up to a variation of 20% in comparison to the threshold values established by the Commission, in order to refine the classification and mapping of soil ecological status within their territory."

Comment:

Given the premature character of most soil health criteria listed in Annex I and II, the high variability of soil properties, climate and ecological conditions across Europe, and the poor technical quality of the SML proposal, I seriously doubt that the establishment of threshold values (criteria) should be left to the Commission without agreement of the Member States.

Moreover, the deviation from such thresholds by 20% by the Member States is not supported by any scientific evidence. This is an arbitrary approach, ignoring differences between soil health descriptors and their variation across Europe.

4. CLUSTER 3 (CHAPTER IV)

No comments as I expect that this will be covered by input from the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation & Technology.

5. CLUSTER 4 (CHAPTERS III & V)

Regarding Cluster 4, I will concentrate on Articles 10. This does not mean that I agree to all other provisions summarized under this cluster.

5.1 SUSTAINABLE SOIL MANAGEMENT (Article 10 including Annex III & IV)

Comments:

The principles, programmes and plans for improving / restoring soil health do not address the most important leverages for soil and environmental policy that would be required to improve soil health in Europe substantially. In the scientific community it is largely agreed that the pressure on soils needs to be decreased by supporting diet shifts toward more direct use of plant calories, and decreasing the food waste. Also cascade use of food waste that cannot be avoided should be implemented more stringent in EU policies. Enhancing food security and self-sufficiency and the production of biochemical, biomaterials and bioenergy (bioeconomy sector) in Europe is to some extent competing with the objectives for restoring soil health, climate change mitigation / adaption, restoring biodiversity and ecosystems etc. This can only be resolved by the consequent implementation of effective policies to promote diet shifts and food / biomass waste avoidance that reduce the area of soil required for production.

Therefore, the directive, in addition to the items listed in Annex III and Annex IV, should define programmes and plans that provide a substantial leverage for achieving the objectives. This should, include:

- More stringent regulation of animal production in Europe
    - Binding animal numbers to the carrying capacity of animal-producing farms
    - Limiting feed production on cultivated land to farms with animal production
    - Increasing taxation on feed imports
    - Measures to avoid substitution of animal products by imports to the EU
- More stringent regulation of food / biomass waste

- Socio-economic policies including transitional support that ensure that the implementation of the measures listed above shall keep food prices for producers (farmers) and consumers at reasonable level.

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