

Food and Agriculture Organization of the United Nations

Determination of the clay content of soils 25 June 2024



Indicators soil health based on the relation between soil organic matter and clay

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Clay: 3% Sand: 93% Topsoil pH (CaCl₂): 4.7 Topsoil TOC: 2.9% SOC stock (0-100 cm): 132 Mg ha⁻¹ Plant available water: 58 mm



Tschernozem



Clay: 23% Sand: 4% Topsoil pH (CaCl₂): 7.1 Topsoil TOC: 2.0% SOC stock (0-100 cm): 213 Mg ha⁻¹ Plant available water : 220 mm





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Clay content – a central soil property

- is hardly affected by land use or climate
- is result of pedogensis and bedrock
- is pivotal for the water retention function of soil
- is essential for soil carbon stabilisation



Eyles et al. 2015, Soil Res.





Clay in relation to soil organic carbon



Relative variable importance

Webb et al. 2003, SSSAJ

- Mäkipää *et al.* 2024, Geoderma
 - Clay is main predictor for soil carbon at large scale
 - Clay defines a lower limit for SOC







Soil inventories. e.g. in Germany at national scale



- Sampling grid of 8 × 8 km (3104 sites)
- Uniform depth increments:

0-10, 10-30, 30-50, 50-70, 70-100 cm

- 124.000 soil samples
- Firt completed inventory: 2012-2018
- > Data are open access available:

https://doi.org/10.3220/DATA20200203151139





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Soil organic carbon in Germany

Topsoil (0-30 cm)



THÜNEN

Subsoil (30-100 cm)





Soil texture in Germany



Gebauer et al. 2022, Frontiers Soil Sc.

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Soil texture in agriculture



 Distribution of agriculture in Germany across texture classes is uneven

Soil texture: The standard soil parameter with the most time consuming analytics.





Texture and C/N ratio



Poeplau *et al.* 2020, JPNSS



Exception: Some sandy soils,
 former heathlands and peatlands
 (C/N>13)

So called **Black sands** can be

found also in The Netherlands

and Denmark







Clay and SOC-fractions



Clay content determines the fraction of particulate organic carbon (light fraction)





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Clay: 23 mass% Sand: 4 mass% Topsoil pH (CaCl₂): 7.1 Topsoil TOC: 2.0% SOC stock (0-100 cm): 213 Mg ha⁻¹ Plant available water : 220 mm

Are these soils in healthy conditions or degraded?

Tschernozem







Podzol



Soil health indicators

- Should be sensitive to land management and climate (in contrast to soil quality indicators)
- Should be **relevant** due to its relation to soil functions
- The indicator should be measurable with reasonable effort (accessibility)
- Should inform land managers and policymakers

| STATUS AND TRENDS | | | DRIVERS AND PRESSURES | |
|--|--|---|--|---------------------------------------|
| Observable soil properti (Measurements) SOC. N. P Textural classes. structure pH Depth. stone content, mineralog Bulk density Water content, soil temperature Soil biota (micro, meso, macro) Cation and anion content (contaminants, nutrients, acidifiers salts) | Physical properties Chemical properties Biological properties | Derived soil properties (Modeling) Porosity Aggregate stability Rooting depth Cation exchange capacity Electric conductivity Hydraulic conductivity Water runoff, infiltration Erodibility Adsorption and cation exchange capacity | External (environm factors (climate, la emissions) Non-Soil ind | ental) nd use, inputs, dicators |
| Soil quality sets the condition for Soil threat indicators Soil nutrient loss – N and P Soil acidification Soil pollution Soil pollution Soil biodiversity loss Soil erosion Conditioning the extend of soil threats | Soil functional indicators Biomass productivity Water storage capacity | Soil functions Food production Water retention | Ecosystem services Provisionir | |
| | iffect on soil functions | Soil moisture deficit Groundwater reproduction Carbon storage capacity | Water purification and regulation Carbon pool and climate regulations | Regulation |
| Soil compaction Salinisation (*) Soil sealing | | Nutrient mobilisation and buffering capacity Habitat provision capacity | Nutrient dynamics Habitat | Supporting |
| | Thresholds Critical levels | | | Î |
| Level to which soil functions are fulfilled | | | IMPACT | |





SOC/clay ratio as indicator

- Attempt to turn SOC levels into a soil health indicator
- Normalisation for clay as main SOC driver
- Clear relation of SOC/clay to soil physical parameters



Johannes et al. 2017, Geoderma





SOC/clay ratio as indicator



- We applyed SOC/clay ratio to 2958 agricultural soils in Germany
- Almost all clayey soil were "degraded"
- Almost all sandy soils were "very good"
- Normalisation with clay is too strong
- U We propose an alternative ratio:
 - SOC/SOC_{exp}
- With SOC_{exp} as the expected SOC content using a SOC~clay regression/model
- Poeplau and Don, 2023, Soil use manag



SOC/SOC_{exp} indicator for soil structure

SOC/SOC_{exp} can better predict soil porosity than SOC/clay

SOC/clay should not be used as soil health indicator



Poeplau and Don, 2023, Soil use manag







Clay lab analysis vs. texture by feel





- Texture by feel analysis (estimation) by trained soil scientists has surprisingly high precision compared to lab measurement (measurement)
- It can substitute time consuming lab analysis in some cases







Conclusions

- Clay is a key parameter for soil quality
- Clay and soil carbon are closely linked
- Also soil carbon quality is related to soil texture
- SOC/clay ratio is a biased indicator for soil health
- Clay content need to be accounted for to
 differentiate between managable (soil health) and
 static (soil quality) soil parameters.











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Thank you



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