

On-site Wastewater Management Training Course

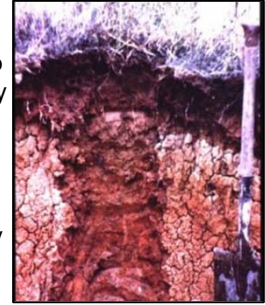
Soil Assessment for On-site Wastewater Management

Honorary Associate Professor Phillip Geary
School of Environmental & Life Sciences
The University of Newcastle NSW

Centre for Environmental Training cet

Site and Soil Evaluation (SSE)

- Soils are examined as part of an SSE or LCA to determine their capability to assimilate and treat domestic wastewater
- Aim is to determine if wastewater can be managed within property boundaries
- A range of important physical and chemical soil features are investigated in the field or samples may be collected for later detailed analysis



Centre for Environmental Training cet

Soil Assessment

- Minimum of three observation boreholes should be investigated — see Appendix D3 AS/NZS1547:2012
- Excavation of a borehole or soil pit to determine location of best soils undertaken by;
 - backhoe (may not be economic)
 - hand digging or corer or
 - soil auger
- Minimum depth should be 600mm below the proposed point of application, or to refusal — AS/NZS 1547 and VIC Code require 1.5m below point of application, NSW Guideline suggests 1.2m



Soil Augering/Excavation

- Layout in order of recovery; do not spread out
- Identify differences by feel when augering
- Decide on horizons or layers and describe including depth
- Number horizons/layers, look at important properties and record soil borelog for location



cet

Soil Borelog and Profile Description



Depth (m)	Horizon (Layer)	Texture	Structure	Colour	Mottles
0.3	A ₁	SCL	Moderate	Dark Grey	Nil
0.6	A ₂	SCL	Moderate	Grey Brown	Nil
1.2	B	LC	Weak	Strong Yellow	Red and Gley
> 1.2	C	Broken Down Parent Material			

Describe the properties of soil **horizons or layers** which can be distinguished from those above and below e.g. topsoil and subsoil

Centre for Environmental Training cet

Key Soil Questions

- What is the depth of soil and what are the features of each layer or horizon present?
- Soil colour and mottling (if present); is soil saturated or water table encountered?
- % of coarse fragments (rocks and nodules) and cracks which may affect drainage; is there weathered rock or bedrock?
- What is the soil's texture and structure?
- Is the soil dispersive and/or sodic?
- Water in soil – what do the terms porosity, suction and permeability mean?
- How do we use information obtained from our soil to determine the design loading rate (DLR) or design irrigation rate (DIR)?

Centre for Environmental Training cet

Soil Colour

Reflects the underlying mineralogy of the soil, also its fertility, and ability to drain (permeability). Generally speaking:

- **dull** colours indicate wetness during formation (iron reduced to ferrous form)
- **pale** colours may be from pale rocks (e.g. rhyolite) or leached from darker minerals
- **dark** colours may be from dark rocks such as basalts or contain high levels of organic matter
- bright **red** colours from well aerated soils with high iron and aluminium content
- **bleached** (pale) - minerals removed by water



Centre for Environmental Training

cet

Soil Mottling

- Is if more than 10% of soil is of a contrasting colour
- Important indicator of soil drainage characteristics
 - colour different from main soil colour, may be spots, blotches or streaks
 - bright colours (orange and yellow) – indicative of oxidising conditions
 - very dull grey colours – strong iron reduction (gleying) – saturated or anoxic conditions
- Mottling indicates periodic waterlogging



Centre for Environmental Training

cet

Soil Waterlogging

- Important to identify the reason for wetness in SSE
- Could be due to shallow groundwater or seepage from upslope areas and may be permanent or seasonal
- Perched water tables may also occur
- Look for limiting horizons such as shallow hardpan (e.g. coffee rock, iron pan) with waterlogging features such as mottling or gleying



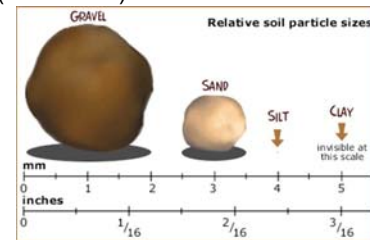
Centre for Environmental Training

cet

Soil Particle Size and Texture

Soil textures are classified according to the relative proportions of different particle sizes being present:

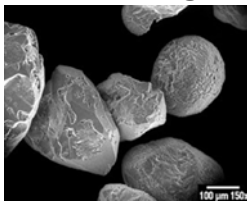
- sand (0.02-2mm),
- silt (0.002-0.02mm)
- clay (<0.002mm)



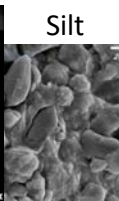
Centre for Environmental Training

cet

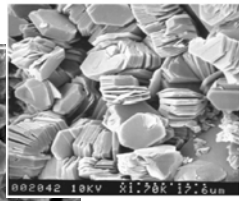
Scanning Electron Micrographs



Sand



Silt



Clay

- Sand is a granular material composed of finely divided mineral particles – it is defined by its grain size with the most common constituent being silica which is inert and hard

- Clay minerals are flat, like pages in a book, with the space between the platelets being variable and being filled with water and exchangeable cations

Centre for Environmental Training

cet

Soil Particle Size and Texture

- Examine soil texture in soil pit or on sample – important for soil drainage
- The relative proportion of sand, silt and clay in a soil sample
 - can be determined by laboratory sieving methods (PSA) and fractionation and/or
 - using a field textural method (ribbon test)



Field Textural Determination

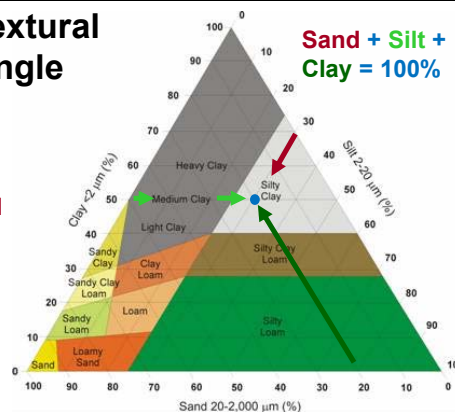
- 'Ribbon Test' developed to provide a fast and repeatable method for field description of in-situ soil texture
 - a subjective test
 - requires practice and skill development
- Determine relative proportions of silt, sand and clay fractions based on moistened bolus
- Used to assess soil hydraulic capacity and infer design loading rate (DLR)
- Will be practiced in workshop later



Centre for Environmental Training cet

Soil Textural Triangle

50% Clay
20% Sand
30% Silt



<https://soilquality.org.au/FactSheets>

Centre for Environmental Training cet

Soil Texture Groups

Texture Group	Texture Grades
Sands	sand, loamy sand, clayey sand
Sandy loams	sandy loam, fine sandy loam
Loams	loam, silty loam,
Clay loams	sandy clay loam, clay loam, silty clay loam, fine sandy clay loam, sandy clay
Light clays	silty clay, light clay, light medium clay
Medium-heavy clays	medium clay, heavy clay

Centre for Environmental Training cet

Soil Structure

- Arrangement of soil particles into natural aggregates (peds)



- Describes the distinctness, size and shape of peds
- Described in terms of structureless, massive, weak (peds indistinct), moderate or strong structure (peds distinct)

Centre for Environmental Training cet

Soil Structure

- Should be described from a 'fresh' vertical exposure
- CANNOT be assessed from an augered hole
- Soil structure affects; permeability, aeration, drainage, erosivity, surface condition, stability and general soil productivity

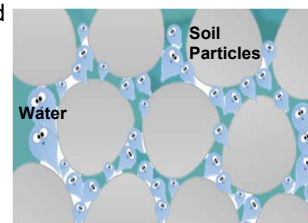


Drop Test Method



Water in Soil – Porosity

- Portion of soil occupied by air and water
- Determined by arrangement of solid particles
- Sands have large pore spaces between the particles, but few compared to silt or clay
- Soil pores may contain part solid matter, water and air



Range of porosities as %

- Sands - 25-50
- Silts - 35-50
- Clays - 40-70

Centre for Environmental Training cet

Water in Soil – Suction

- Soil is hydrophilic – attracts water to its surface very strongly
- All soil pores act as capillaries; capillary forces control water movement between voids
- Suctions can be measured
- Sands contain mostly large pores so these can only be full at low suctions; clays with mainly smaller pores, require a wider range of suctions



Sponge

Soil Water Terms

- Saturation
- Field Capacity
- Wilting Point

Centre for Environmental Training cet

Water in Soil - Permeability

- Permeability or hydraulic conductivity is the velocity of movement of a fluid (water) through a porous medium relative to the pressure gradient (hydraulic head) which brings about the movement
- Not possible to precisely correlate percolation with permeability
- Percolation was determined by a falling head "perc" test and is **no longer used**



Centre for Environmental Training cet

Water in Soil - Permeability

- Can be measured in a laboratory under standard conditions involving a constant head of water
- In lab soil placed in columns (necessary to know soil bulk density) and loaded at a known rate



Lab

Centre for Environmental Training cet

Water in Soil - Permeability

- Can be assessed in field or lab by a determination of soil texture and structure (demonstrated at this course)
- Relationship exists between soil texture and structure and indicative clean water permeability - see tables in AS/NZS 1547:2012 (Table 5.1)
- Typically coarser grained soils have higher K_{sat} than fine grained; some fine-grained soils can have higher K_{sat} due to structure such as cracking



Assessed

Centre for Environmental Training cet

Water in Soil - Permeability

Texture Group	Typical Permeability K_{sat} (m/d)
Gravels and sands	> 3.0
Sandy loams	1.4 – 3.0
Loams	0.5 – 1.5
Clay loams	0.06 – 1.5
Light clays	< 0.06 – 0.5
Medium-heavy clays	< 0.06

- Values based on movement of water not effluent through soil
- Using determined soil category necessary to use tables in AS/NZS1546 to select DLR/DIR for preferred land application system

Centre for Environmental Training cet

Field Permeability

- Can be measured in field using permeameters – rely on constant head (see Appendix G AS/NZS1547:2012), Talsma-Hallam, Guelph and Cromer permeameters

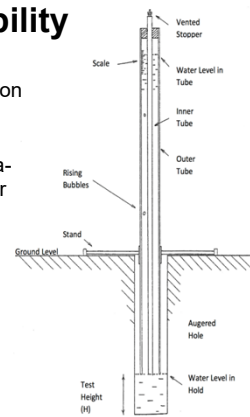


Figure 1: Schematic of a constant head tube permeameter

Other Key Soil Features

- **pH** – acidity/alkalinity
- **Electrical Conductivity** - salinity
- **Emerson Aggregate Class (EAC)** - soil structural stability and susceptibility to erosion
- **Cation Exchange Capacity (CEC)** - capacity of soil to hold and exchange cations (positively charged molecules)
- **Exchangeable Sodium Percentage (ESP)** - indicator of soil sodicity which affects soil structural stability and overall susceptibility to dispersion
- **Phosphorus sorption (P_{sorb})** - direct measure of ability of soil to adsorb (bind) phosphorus



Some Problem Soils

- **Dispersive Soils** - soil aggregates collapse when the soil gets wet by fresh water because the individual clay particles swell and disperse into solution. Collapse of structure causes the soil to slump, lose porosity and permeability and restricts root growth of most plants



- **Sodic Soils** – soils with a high percentage of exchangeable sodium can be dispersive as well. When ESP > 6, soils are considered sodic and can become impermeable

<https://www.agric.wa.gov.au/dispersive-and-sodic-soils/identifying-dispersive-sodic-soils>
Centre for Environmental Training



Further Reading

- AS/NZS 1547:2012 On-site Domestic Wastewater Management
- AS 1726:2017 Geotechnical Site Investigations, Standards Australia, SAI Global, Sydney, NSW.
- Geary, P.M., Whitehead, J. & Patterson, R. (1999) Skills to Assess the Suitability of Sites for On-site Wastewater Disposal, Environmental Health Review - Australia, 28, 2, 42-47.
- <https://soilquality.org.au/> Fact Sheets on Soil Texture
- <https://www.agric.wa.gov.au/dispersive-and-sodic-soils/identifying-dispersive-sodic-soils>
- McKenzie N, Coughlan K and Cresswell H (2002) Soil Physical Measurement and Interpretation For Land Evaluation, CSIRO Publishing: Collingwood, Victoria.
- van de Graaff, R.H.M & Alexander, J. (2008) The Percolation Test – A Test with False Pretensions, in Onsite and Decentralised Sewerage and Recycling Conference Proceedings – Australian Water Association, Sydney, NSW.

Centre for Environmental Training



