On-site Wastewater Management Training Course

Soil Assessment for On-site Wastewater Management

Centre for Environmental Training cet

Soils of New Zealand

- 15 dominant Soil Orders identified in NZ and used to classify soils according to:
  - Physical and chemical characteristics
  - Morphology (appearance)
  - Soil Form (parent material, particle size and permeability)
- Brown (43%); Podzols (13%); Pallic (12%); Allophanic (5%); Recent (6%); Pumice (7%); Raw (3%); Gley (3%); Ultic (3%); Semi-arid (1%); Granular (1%); Melanic (1%); Organic (1%); Anthropic (<1%) and Oxidic (<1%)
- Broadly distributed based on geological, geomorphic and topographic conditions

Centre for Environmental Training cet

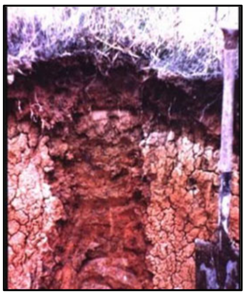
Soil Formation - Geology

- Igneous:
  - Volcanic (eruptive) – fine grained basalts – weather to form clays, little quartz
  - Plutonic (intrusive) – coarse grained granites, weather to sandy soils; high quartz, often duplex
- Sedimentary:
  - Marine – shallow and deep water deposits
  - Terrestrial – formed on land by water, wind and gravity
- Metamorphic:
  - Igneous and sedimentary material crushed, compressed and deformed by pressure and/or temperature

Centre for Environmental Training cet

Site and Soil Evaluation (SSE)

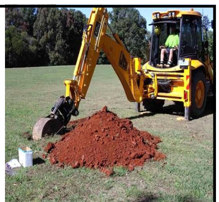
- Soils are examined as part of an SSE or LCA to determine their capability to assimilate and treat domestic wastewater
- Aim is to determine if wastewater can be managed within property boundaries



- A range of important physical and chemical soil features are investigated in the field, with samples collected for later detailed analysis

Centre for Environmental Training cet

Soil Assessment



- Minimum of three observation boreholes / one (1) soil pit investigated (Appendix D3 - AS/NZS1547)
- Excavation of borehole or soil pit to determine location of best soils undertaken by:
  - backhoe (if 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 requires 1.5m below point of application

Centre for Environmental Training cet

Soil Augering / Excavation

- Layout in order of recovery; do not spread out
- Identify differences by feel when augering
- Differentiate horizons or layers and describe, including depth or thickness
- Number horizons / layers, identify important properties and record soil borelog for location
- Rooting depth, soil moisture, colour changes etc.

Centre for Environmental Training 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/ Orange	Red and Gley
> 1.2	C	Broken down Parent Material	Massive	Orange	Nil

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

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

- 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
- <u>Mottling indicates periodic waterlogging</u>

Mottled soil

Centre for Environmental Training cet

Soil Waterlogging

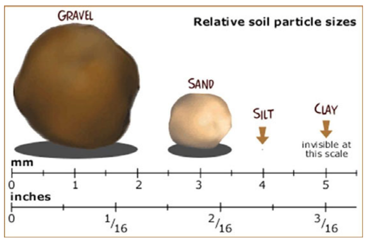
- Important to identify the reason for wetness in SSE
- Could be due to shallow groundwater or seepage from upslope areas and may be permanent or seasonal
- Perched water tables may also occur
- Look for limiting horizons such as shallow hardpan (e.g. coffee rock, iron pan) with waterlogging features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

Gleyed soil

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 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

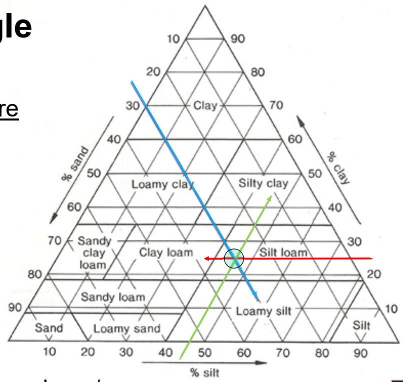
Soil Particle Size and Texture

- Examine soil texture in soil pit or in a collected 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)

Soil Textural Triangle

Silt loam texture

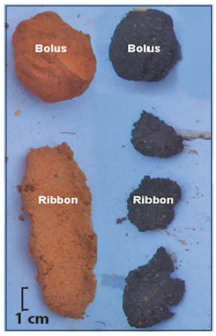
- 25% clay
- 45% silt
- 30% sand



https://soils.landcareresearch.co.nz/

Field Textural Determination

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



Soil Texture Groups

Texture Group	Texture Grades
Sands	sand, loamy sand, clayey sand
Sandy loams	sandy loam, fine sandy loam
Loams	loam, silty loam, loamy silt
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

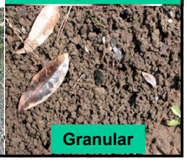
Soil Structure

- 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)

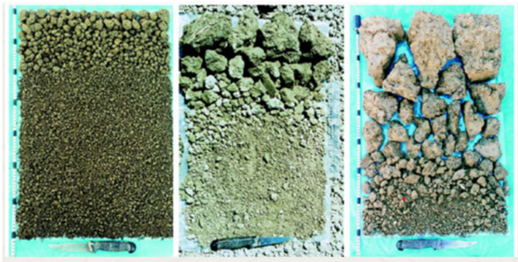
Soil Structure

- 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



Soil Structure

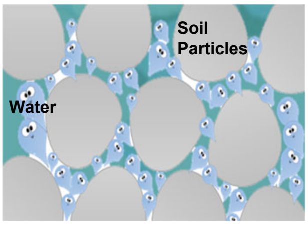
- Visual assessment of soil structure



Visual assessment of soil structure. Good condition (left), moderate condition (middle), and poor condition (right). Source: MWLR

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



<u>Range of porosities as %</u>

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

Water in Soil – Suction

- Soil is <u>hydrophilic</u> – 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

<u>Soil Water Terms</u>

- Saturation
- Field Capacity
- Wilting Point

Water in Soil - Permeability

- Can be <u>measured</u> 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

Water in Soil - Permeability

- Can be <u>assessed</u> in field or lab by a determination of soil texture and structure (demonstrated here)
- Relationship exists between soil texture and structure and indicative clean water permeability - see Tables 5.2 in AS/NZS 1547:2012
- 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

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
- Use tables in AS/NZS1547 to select appropriate DLR / DIR for preferred land application system, based on determined soil category

Field Permeability

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

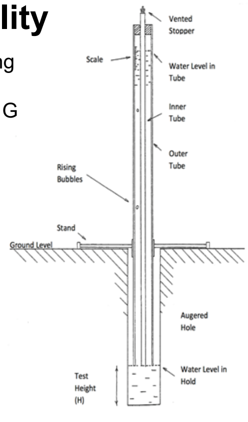
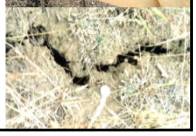


Figure 1: Schematic of a constant head tube permeameter

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

- Unstable Soils - soil aggregates collapse when wet by fresh water because the individual clay particles swell and cloud the solution (dispersion). Collapse of structure causes the soil to slump (slake), lose porosity and permeability and restricts root growth of most plants

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

Local Examples

- Pallic Soils – 12% cover in NZ – very high density (silt fraction. Dry in summer and wet in winter. Found in the seasonally dry eastern part of the North and South Islands
- Semi-Arid Soils – 1% cover in NZ – in areas of <500mm annual rainfall. Occur in the inland basins of Otago and southern Canterbury. Can be classed as 'sodic'
- Ultic Soils – 3% cover in NZ. Common in the northern North Island and in the Wellington, Marlborough, and Nelson region

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
- Milne, J.D.G, Clayden, B., Singleton, P.L. and Wilson, A.D. 1995.Soil Description Handbook. Revised Edition. Manaaki Whenua Press. Canterbury
- 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.