AUSTRALIA

Section 9

Assessment of Soils for On-site Effluent Disposal

Practical Exercises

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SOIL PHYSICAL AND CHEMICAL PROPERTIES

Review: The return of domestic effluent (water, chemicals and microorganisms) to the hydrologic cycle generally occurs through the application of effluent to a soil. The ability of that soil to further treat the effluent is critical to the ultimate evaporation or drainage of the water, without degrading the soil's physical, chemical or biological properties. The soil acts as a microfine filter, a chemical capture device, an aerobic treatment system and a tertiary biological treatment facility. To this end, wastewater management must address the physical and chemical properties of both the wastewater and the soil.

A soil that exhibits a tendency to be structurally unstable when exposed to low salinity water (EC <1 dS m^{-1}) may present a significant problem when exposed to domestic wastewater, either immediately or after a period of contact.

Figure 1 Soil aggregates

When an air-dry ped (aggregate) is placed in low salinity water, some soils rapidly fall apart upon wetting (slake), others fall apart more completely (disperse) while others are water stable (maintain integrity). Slaking occurs as the trapped air bubbles force their way out through the soil mass and dislodge soil particles as they escape. When the soil further dissociates to release colloids as a cloud around the soil mass, dispersion has occurred.

Slaking soils can be remediated by increasing organic matter content. Ameliorating dispersive soils requires increasing the electrolyte concentration of the soil water and/or reducing the impact of sodium in the soil matrix. While dispersibility may be an inherent property of a soil, its significance can be increased by changes to soil chemistry induced by wastewater chemistry. High wastewater pH may also induce dispersion.

The measurable effects of increased soil dispersibility include:

- hard setting surface;
- reduced infiltration (movement of water from the surface into the soil);
- reduced permeability (movement of water downwards through the soil);
- piping and tunnelling within the soil;
- loss of soil structure (shape of the soil aggregates); or
- poor vegetative growth (deficiencies, toxicities, moisture relations).

Two demonstrations provide:

- a comparison of the effects of water and wastewater upon several soils; and
- the effects of salinity on dispersed soils.

Five exercises are arranged to provide practical experiences in:

- determining soil structural stability
- measuring electrical conductivity
- measuring soil pH
- describing the soil's texture by field methods.
- describing the soil profile.

Demonstration 1
EFFECTS OF WASTEWATER ON SOIL PERMEABILITY

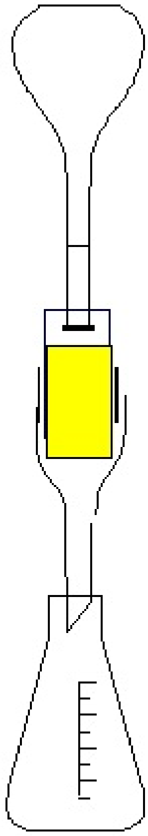


Figure 2

Review: The quality of wastewater varies widely within and between domestic systems, in electrolyte concentration (measured as electrical conductivity), pH and sodium adsorption ratio. Variations occur in response to water volumes and chemicals entering the tank from various uses within the house such as from toilets, washing machines or kitchen wastes.

This demonstration highlights the ease with which an effluent, high in sodium salts can alter the permeability of a soil column within a short period. Laundry detergents may provide a high relative concentration of sodium salts (sodium adsorption ratio) as well as a high pH, both properties which enhance dispersion in soil.

The soils that have been chosen for this demonstration represent typical soils to which effluent is applied. The wastewater is typical of the discharge from an automatic washing machine using a powder laundry detergent.

For each of the five soil columns, one column is treated with clean rainwater (SAR=0) and a second column with laundry water (SAR=15).

The laundry detergent used in this demonstration has a pH of 10.95, an EC of 2.85 dS/m and a sodium load of 98 g Na/wash (650 mg Na/L) when mixed at the manufacturer's recommended dose for the complete top loading cycle.

Table 1. Effects of water chemistry on soil permeability

Start Time: End Time: Elapsed Time:

Soil type	Volume of leachate (mL)		Colour of leachate		Suitability for on-site disposal
	Clean water	Laundry water	Clean water	Laundry water	
1					
2					
3					
4					
5					

Point to consider:

- Differences in permeability reflect effects of effluent chemistry.
- Differences in leachate colour reveal particulate (colloid) movement.
- Differences between different soils occur due to soil properties.

Note: *This is a demonstration, not a trial because of lack of controls and replication*

Demonstration 2
EFFECTS OF INCREASING SALINITY ON DISPERSION

Review: Ameliorating the effects of wastewater chemistry on dispersive soils can be replicated by demonstrating the effects of flocculation on a totally dispersed soil. Flocculation (the opposite to dispersion) occurs when the nett negative charge on colloidal surfaces is neutralised. Negative charges are neutralised with positive charges. While aluminium is the most efficient flocculating agent, calcium is also used to avoid the toxic effects of aluminium. Calcium salts (gypsum, line, dolomite) also provide essential plant macro-nutrients. Sodium can also cause flocculation at very high levels when a muddy river discharges into the sea (EC 34 dS m^{-1}).

Demonstration

A small quantity (2.0 g) of a soil is added to each of five 250 mL measuring cylinders and filled with deionised water. The cylinders are treated in the following way:

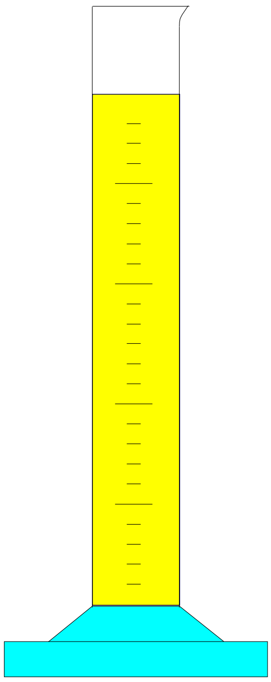


Figure 3

1. Control - no chemicals added.
2. Sodium chloride at rate of 1000 mg Na^+ L^{-1}.
3. Potassium chloride at rate of 1000 mg K^+ L^{-1}
4. Calcium chloride at rate of 1000 mg Ca^{2+} L^{-1}
5. Aluminium chloride at rate of 1000 mg Al^{3+} L^{-1}

The cylinders are shaken vigorously in turn and allowed to stand. The time is noted. ....

After a period, make a visual examination of the five cylinders and report on the turbidity of the top 100 mL of the water column. Place a white paper on which heavy black printing has been made and rate the clarity of the column by the ease with which the writing can be read.

Table 2. Observed effects compared with control

Cylinder and treatment	Clarity rating	Effect of added salt	pH	EC (dS/m)
1. control (nothing added)			6.60	0.005
2. sodium addition			6.30	3.75
3. potassium addition			6.35	2.80
4. calcium addition			6.03	4.12
5. aluminium addition			3.25	6.75

Clarity rating: 0 = cannot distinguish writing; 1 = can see shadow of writing;
2 = can see individual letters but cannot read; 3 = can read letters; 4 = reading very clear

EXERCISE 1. DETERMINATION OF SOIL DISPERSIBILITY

Outline: This exercise will require the student to carry out the ***first*** part of the Emerson's Dispersion Test and comment upon the suitability of the soil for effluent application.

Procedure:

As a group:

take five petri dishes labelled 1 to 5, remove lids
place each dish on the marked sheet supplied

two-thirds fill each dish with **deionised** water

take **three to five** soil peds (about 5 mm cross section) from each of the set of five soil peds, noting from which sample they were taken

drop the peds gently into the water in the correctly labelled dish, cover the dish and leave undisturbed. Avoid bumping the dishes

examine the peds after one hour, refer to Table 3.

(This is only the first part of the Emerson's dispersion test, the second part will be explained and demonstrated but not undertaken.)

Emerson's original aggregate observation was made after 16 hours

It would be usual to examine the dispersibility of the soil in the actual wastewater. Water of SAR 5 with an EC less than 1 dS m^{-1} should be used to simulate domestic wastewater.

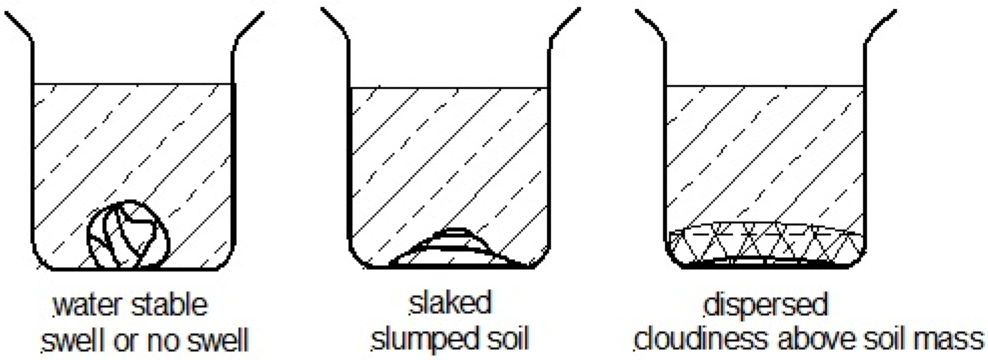


Figure 4 Three states of aggregate stability

Observations

Water Stable	(soil ped maintains same shape, may swell)
Slaking	(soil ped falls into a sludge type material)
Dispersion	(clay particles cloud the water around the soil)

EXERCISES 2 & 3 . ELECTRICAL CONDUCTIVITY and SOIL pH

Background:

When soil is mixed with water in a given ratio, two important soil properties can be measured using inexpensive hand-held equipment.

Electrical conductivity

Firstly, as the soil forms a suspension in water , soluble salts dissociate in the water to form equal amounts of positive and negative ions. The typically these ions may include Na^+, Ca^{2+}, Mg^{2+}, K^+, Al^{3+}, H^+, Cl^-, SO_4^{2-}, CO_3^{2-}, HCO_3^-, and many others.. The organic acids, the breakdown products of organic matter and decaying microbes also provide other positive and negative ions.

As the salt content increases, the effect of these ions decreases the electrical resistance in the water, that is, the water conducts an electric current more easily. The EC in a simple linear relationship to concentration - twice the EC means twice the dissolved salt content. However, it is not possible to determine which ion has the greater concentration by this method.

Soil pH

Soil reaction (pH) is a relative measure of the acidity of the soil, that is, the amount of hydrogen ions (H^+) present on a logarithmic scale. When hydrogen ions are dominant (pH <7), the soil is classified as acid. When hydroxide ions (OH^-) dominate (pH >7), the soil is classified as alkaline. pH 7 is termed neutral. There are no units for pH.

Under acid conditions, elements such as iron, aluminium, manganese and the trace elements (zinc, copper, chromium) become highly soluble and may create problems for vegetation. Aluminium at pH 4 is readily available and highly toxic to plants.

Under alkaline conditions, nitrogen becomes less available and calcium and magnesium precipitate out of the soil solution. High concentrations of sodium can produce an alkaline soil reaction.

Equipment

- soils labelled 1 to 5
- 5 x 50-mL centrifuge tubes with lids
- 1 Hanna DiST EC meter, pre-calibrated
- 1 pack of pH test strips
- 1 spatula (scoop)
- 5 x 60 mL plastic jars without lids

Procedure

As a group

- stand five 50-mL centrifuge tubes labelled 1 to 5, in five similarly marked jars
- into each tube place soil up to the 7.5 mL mark
- fill the tube to the 45 mL mark with deionised water, replace cap (this represents about a 1:5 soil:water solution)
- shake each tube for about 10 seconds, once every 10 min for 30 min.

NOTE: N.Z. soil scientists prefer a 1:5 soil:water suspension for EC, and a 2:5 soil:water suspension for pH. Whichever ratio you use, you must ALWAYS refer to the ratio when reporting the results. AS/NZS 1547:2012 does not refer to any ratio.

EXERCISE 4. FIELD TEXTURE ANALYSIS

Review: Classification of soil by texture refers to the relative proportions of sand, silt and clay present. While several laboratory methods are used for determining these proportions, the field texture test allows an experienced person to evaluate the texture with a reasonable degree of confidence when compared to the particle size analysis method. The practical range of permeability is conferred from the field texture analysis together with the indicators of other important parameters such as soil structure, colour, horizons, and organic matter.

TABLE 3. SOIL CATEGORY ACCORDING TO AS/NZS 1547:2012

Soil category	Soil texture	Soil category	Soil texture
1	gravels, sands	4	clay loams
2	sandy loams	5	light clays
3	loams	6	medium, heavy clays

Equipment: Each group will have five soils (1-5), a spray bottle and deionised water.

Procedure

- Individually take a small quantity of soil in the palm of your hand (approximately one tablespoon full);
- spray soil with water;
- knead until the ball of soil just fails to stick to your fingers the bolus should be about the size of a golf ball;
- continue kneading and moistening until no apparent change in the feel of the soil, usually about two minutes;
  NOTE: Should too much water be added, add some more soil.

Figure 5 Forming of ribbon from bolus

- appreciate the feel of the soil (plastic, silty, smooth, sandy) while you are kneading it;
- when the bolus is well formed, squeeze the soil between your thumb and forefinger in an attempt to form a ribbon of soil over your forefinger (this procedure will be demonstrated);
- continue to form a ribbon until the soil breaks away;
- compare the length of the broken ribbon with the Table 5;
- record your findings in Table 4; and
- repeat the exercise for each of the samples.

The range of soils has been chosen to give you a “feel” for the different major soil textural classes.
Determine the texture on EVERY sample provided.

Note: the soils have been air-dried and sieved to minus 2 mm. In the field you may need to remove stones and plant roots before attempting field texture analysis.

Firstly, describe the soil as SAND, LOAM or CLAY

sand: particles are clearly visible to the naked eye, and feel gritty

silt: particles become dusty when dry and easily brushed off the hands

clay: particles are greasy and sticky when wet, hard when dry and have to be washed or scraped off hands (or boots)

TABLE 4. RECORD OF FIELD TEXTURE DETERMINATION.

Soil	Grittiness	Stickiness	Plasticity	Stain	Ribbon (mm)	Grade (Table 5)
1						
2						
3						
4						
5						

Record each of the first four qualities as:

NONE SLIGHT MODERATE VERY EXTREMELY

Grit - sand grains impart a gritty feeling to the soil, sand grains may be visible.

Stickiness - the adhesive forces between different materials, *i.e.* soil and hand. Press the soil between your thumb and your forefinger, observe adherence to your fingers.

Plasticity - property which allows soil to be deformed rapidly, without rupture, without elastic rebound and without volume change - can be moulded into any form by pressure. Try to roll the wet soil into a thin ribbon about 2-4 mm diameter. Plastic soils roll to 2 mm ribbons about 40 mm long.

Stain - some soils leave an obvious stain on the hand from organic materials (black) or minerals such as iron (red).

TABLE 5. TEXTURE GRADE (International System, soil sieved < 2 mm)

	Field Texture Grade		Behaviour of moist bolus	Ribbon (mm)	Approx clay content %
	S	Sand	coherence nil to very slight, cannot be moulded; sand grains of medium size; single sand grains stick to fingers	nil	< 5%
Cat 1	**LS**	Loamy sand	slight coherence; sand grains of medium size; can be sheared between thumb and forefinger to give minimal ribbon of about 5 mm	about 5	about 5%
	CS	Clayey sand	slight coherence; sand grains of medium size; sticky when wet; many sand grains stick to fingers; discolours fingers with clay stain	5 - 15	5% to 10%
Cat 2	**SL**	Sandy loam	bolus coherent but very sandy to touch; will form ribbon; dominant sand grains of medium size are readily visible	15 - 25	10% to 20%
	FSL	Fine sandy loam	Bolus coherent; fine sand can be felt and heard when manipulated; will form ribbon; sand grains are clearly visible under s hand lens	13-25	10% to 20%
Cat 3	**L**	Loam	bolus coherent and rather spongy; smooth feel when manipulated but with no obvious sandiness or “silkiness”; may be somewhat greasy to touch if much organic matter present;	25	about 25%
	ZL	Silty loam	coherent bolus, very smooth to silky when manipulated, will form ribbon	25	about 25%, silt 25%
Cat 4	**SCL**	Sandy clay loam	strongly coherent bolus, sandy to touch; medium size sand grains visible in finer matrix;	25 - 40	20% to 30%
	CL	Clay loam	coherent plastic bolus, smooth to manipulate;	40-50	30% to 35%
	ZCL	Silty clay loam	coherent smooth bolus, plastic and silky to touch	40-50	30%-35% clay, silt 25% or more
	FSCL	Fine sandy clay loam	coherent plastic bolus, fine sand can be felt and heard when manipulated	40-50	30% to 35%
	SC	Sandy clay	plastic bolus. Fine to medium sand can be seen, felt or heard in clayey matrix	50-75	35% to 40%
Cat 5	**SiC**	Silty clay	plastic bolus; smooth and silky to manipulate	50-75	30% to 40% clay, silt 25% or more
	LC	Light clay	plastic bolus; smooth to touch; slight resistance to shearing between thumb and forefinger	50-75	35% to 40%
	LMC	Light medium clay	plastic bolus; smooth to touch; slight to moderate resistance to ribboning shear	75	40% to 45%
Cat 6	**MC**	Medium clay	smooth plastic bolus; handles like plasticine and can be moulded into rods without fracture; has moderate resistance to ribboning shear	> 75	45% to 55%
	HC	Heavy clay	smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; has firm resistance to ribboning shear	> 75	50% +

Source: McDonald, R.C., Isbell, R.F., Spreight, J.G., Walker, J and Hopkins, M.S. (1990) *Australian Soil and Land Survey: Field Handbook. Second Edition*. Inkata Press, Melbourne. Also Northcote (1979).

RESULTS: EXERCISE 1 Emerson Aggregate Test

Observe each of the treatments and compare with the figures below. Report your observations in Table 6.

The Emerson test should also be performed in effluent or irrigation water of the same quality as will be used on the soils under examination. For septic tank effluent, an effluent SAR of 5 with an EC around 1dS m^{-1} should be used to conduct this test.

Figure 6 Water stable aggregates

The difference between the swelling and the non-swelling aggregates may be subtle.

Generally, surface soils with adequate organic matter form stable aggregates.

Unstable aggregates are normal for subsurface soils because of low organic reserves.

Preferable that three grades of slaking are recorded.

Slaking subsoils are not a concern for effluent disposal.

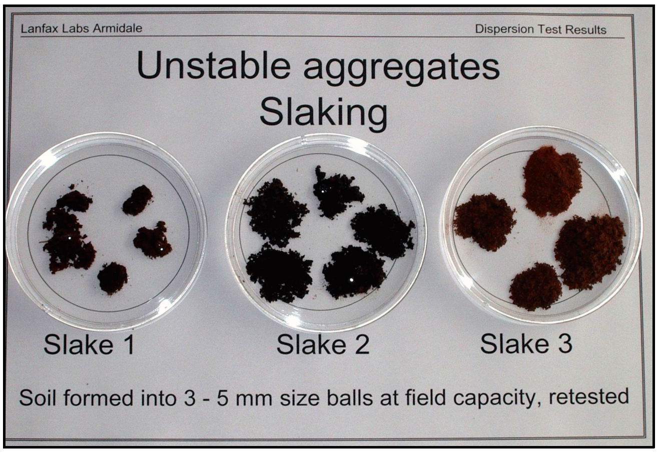


Figure 7 Aggregates that slake to various degrees

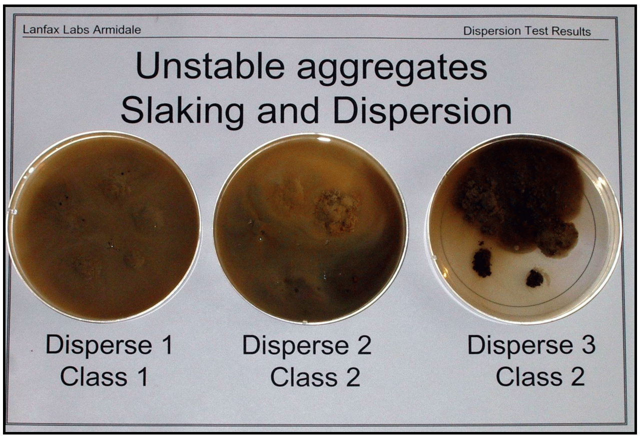


Figure 8 Partial and complete dispersion

Dispersible soils are problem soils where the clay colloids become separated in water and are free to move with the percolating water.

These colloids are sufficiently small to pass through a filter paper, block soil pores and reduce hydraulic conductivity.

Some dispersible soils can be ameliorated using gypsum or lime

EMERSON AGGREGATE TEST - AMENDED

(Reference: Emerson, W.W. (1977) Physical properties and structure. in Russell, J.S. and Graecen, E.L., Eds. *Soil Factors in Crop Production in a Semi-arid Environment*. University of Queensland Press. pp 78-p104.)

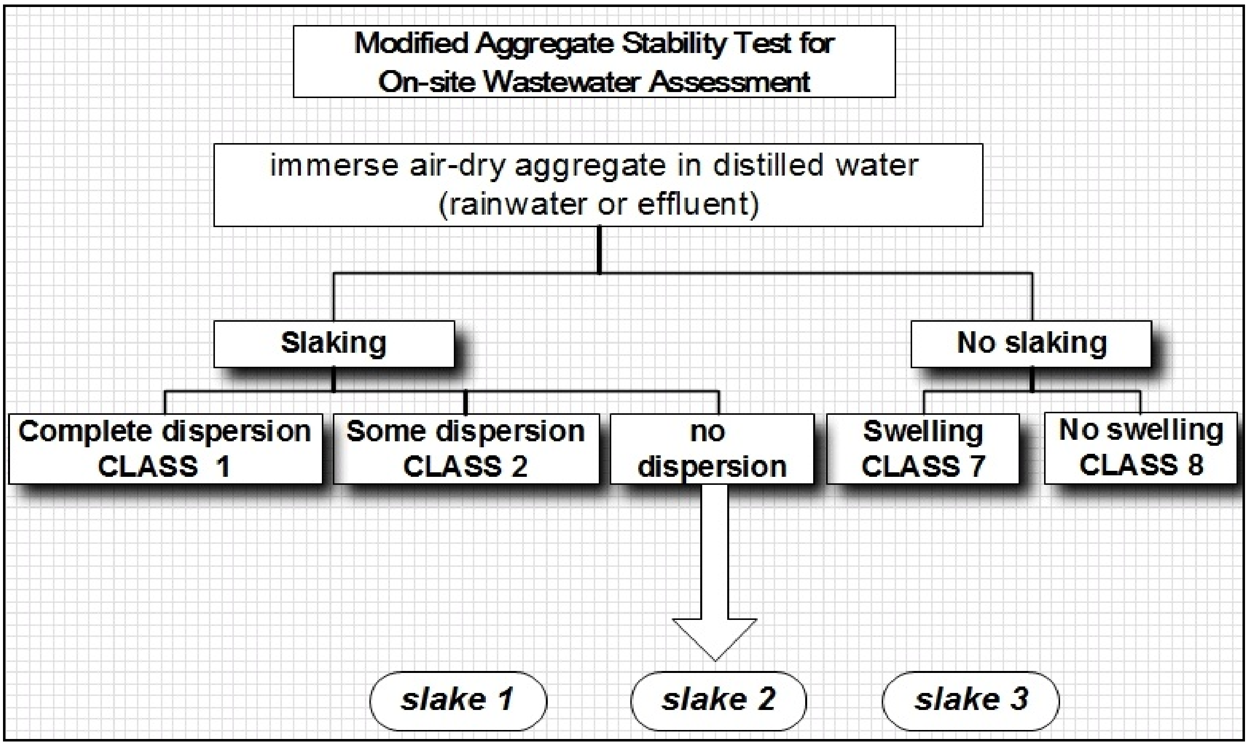


Figure 9 Truncated Emerson Aggregate test for on-site wastewater assessment

Because soils are not physically ploughed (deformed) when wet in an on-site system, the 'remould' component of the original Emerson Aggregate Test is not relevant.

TABLE 6. RECORD OF DISPERSION IN WATER

Soil	Completely Disperse, Class 1	Partially Disperse, Class 2	Slake 1,2 or 3	Water Stable, swell Class 7	Water stable, no swell Class 8
1					
2					
3					
4					
5					

CAUTION: When remoulding the soil sample, the soil is rolled into a small 3-5 mm ball with a plastic spatula, or other non-metallic device, to the consistency of the plastic limit test.

AS/NZS 1547:2012 refers to an amended Emerson Test. However, the procedure outlined in that standard is inconsistent with AS1289.3.8.1 because the amended test uses a sample from the bolus that was used for soil texture determination. Such a practice is not best practice as the salt from the operator's hand, and the excess manipulation render the soil unsuitable as a 'remoulded ped'.

TABLE 7. SOIL AGGREGATE STABILITY

Emerson's test conducted with distilled water. For effluent disposal purposes use effluent

Emerson's Class	Visual Assessment	Description	Suitability for effluent disposal	Results
1	slaking and severe (complete) dispersion	the soil peds slump and a cloud appears around the soil mass, covering bottom of beaker. Subsequent wetting and drying causes crusting, blocking of soil pores decreases permeability. Very poor micro-structure stability. Susceptible to tunnel erosion. Soils high in exchangeable sodium. Add organic matter, treat with gypsum - determine in lab	unsuitable, high ESP, unstable, will require amelioration	
2	slaking and some (partial) dispersion	the soil peds slump and an easily recognised veil of dispersed particles is seen. Becomes more apparent with movement of water. Some decrease in permeability from blockage of pores. Poor micro-structure stability. Add organic matter, treat with gypsum - determine in lab tests.	poor, some loss of permeability, requires amelioration	
3	***no dispersion of air-dried ped*** ***complete or partial dispersion of remoulded soil***	dispersion of remoulded soil, these soils set hard but do not shrink on drying so a crust can form from dispersed soil. Moderate micro-structure stability. Adding gypsum reduces dispersion caused by shearing. Ideal for dam building, because soil can be compacted when wet.	soil severely affected by digging, ploughing	
4	***no dispersion after remoulding***	soil can be remoulded up to field capacity without dispersion when placed in water. Good micro-structure stability. Soil unlikely to crust, resistant to erosion. Contain calcite or gypsum. Good permeability	ideal, not affected by digging	
5	***dispersion after shaking in 1:5 suspension after 5 min.***	remoulded soil: no dispersion under normal agricultural practices because water content outside field capacity. Usually high Ca, Mg. Good permeability.	ideal	
6	***1:5 suspension flocculation after 5 min***	after shaking in 1:5 suspension begins to flocculate within 5 min. complete flocculation, will usually have good soil structure and high permeability.	ideal, good permeability	
7	no slaking, some swelling	peds remain coherent but swell. Soil is water stable, high permeability.	ideal	
8	no slaking, no swelling	peds remain coherent, no swelling, soil is water stable, high permeability	ideal	

It is recommended that the degree of slaking be further rated as 1, 2 or 3 (1=slight, 2= about half slaked and 3=fully slaked.

When remoulding the soil sample, the soil is rolled into a small 3-5 mm ball with a plastic spatula or other non-metallic device. DO NOT use the soil bolus you made in the texture analysis. The small amount of salt from your hands and the excess working may cause the soil to behave differently.

RESULTS: EXERCISE 2 - Electrical Conductivity

Procedure:
AFTER 30 Minutes

- remove cap from tube
- pour liquid into 60 mL plastic container, dip conductivity probe into the solution, ensure that the liquid covers the probe up to the mark
- record meter reading, including the units uS/cm
  (if over-scale, record as >2000 uS/cm
  (meter reads 1 on LHS when over scale)
- rinse probe with deionised water before making next reading
- record all results in the Table 8
- convert all results to deciSiemens per metre
- refer to the attached Table 9 or 10 to determine salinity hazard

At end, rinse EC meter, switch OFF

Figure 10 EC Meter

TABLE 8. RECORD OF EC TESTING
(Reported as EC at 1:5 soil water suspension)

Sample (soil texture)	**EC reading (meter reading) (uS/cm)**	**EC as dS m $^{-1}$ (EC reading / 1000)**	**Salinity hazard** select from Table 9 or 10
SOIL 1			
SOIL 2			
SOIL 3			
SOIL 4			
SOIL 5			

Conversion: 1000 uS cm^{-1} = 1 mS cm^{-1} or 1 dS m^{-1}

Transfer EC value from column 3 to Table 13

Reporting:
It is important that the laboratory, or analyst, reports the method used to determine EC as a reliable interpretation cannot be made without that knowledge.

1:5 soil:water suspension $EC_{1:5}$
Saturation extract EC_{SE} or ECe

Calculation (from Milne *et al.*, 1995)

The following equations give the approximate value for total soluble salts in soil using 1:5 soil:water ratio

Electrical conductivity (dS/m) x 0.35 = total soluble salts (%)

Electrical conductivity (dS/m) x 0.5 = total soluble salts (meq/100 g)

milliequivalents per 100 g (meq/100 g) = centimoles charge per kilogram (cmol(+)/kg)

TABLE 9. RATING, CONDUCTIVITY AND SOLUBLE SALTS FOR NEW ZEALAND (Blakemore *et al.*, 1987)

Rating	Conductivity (dS m^{-1})	% Salts
very high	> 2	>0.7
high	0.8 - 2.0	0.3 - 0.7
medium	0.4 - 0.8	0.15 - 0.3
low	0.15 - 0.4	0.05 - 0.15
very low	< 0.12	<0.02

(Table cited in Milne et al., 1987)

TABLE 10. INTERPRETATION OF SOIL EC

Salinity Hazard	Effect on Plant Growth	Class	EC of 1:5 soil/water extract (dS m^{-1})				
			sand/loamy sand	loam	sandy clay loam	light clay	heavy clay
Non-saline	negligible effect	1	<0.15	<0.17	<0.25	<0.30	<0.40
Slightly saline	very sensitive crops affected	2	0.16-0.30	0.18-0.35	0.26-0.45	0.31-0.60	0.41-0.80
Moderately saline	many crops affected	3	0.31-0.60	0.36-0.75	0.46-0.90	0.61-1.15	0.81-1.60
Very saline	salt tolerant plants grow	4	0.61-1.20	0.76-1.50	0.91-1.75	1.16-2.30	1.61-3.20
Highly saline	few salt tolerant plants grow	5	>1.20	>1.50	>1.75	>2.30	>3.20

(after Cass *et al.*, 1995 cited in Merry, 1996)

Conversion of $EC_{1:5}$ to EC_{SE} (EC_{SE} same as ECe) (Charman & Murphy, 2000)

clay loammultiply $EC_{1:5}$ x 8.6 to convert to EC_{SE}

light claymultiply $EC_{1:5}$ x 7.5 to convert to EC_{SE}

medium claymultiply $EC_{1:5}$ x 5.8 to convert to EC_{SE}

Example:

if the $EC_{1:5}$ in a light clay was 0.45 dS m^{-1} ,

then the approximate EC_{SE} would be 0.45 x 7.5 = 3.38 dS m^{-1} as EC_{SE}

RESULTS: EXERCISE 3. SOIL pH MEASUREMENTS

Procedure

The test is carried out on the sample prepared for EC measurement

- ♦ take the centrifuge tube with the 1:5 soil:water suspension
- ♦ dip a single Merck pH strip into the liquid to wet the coloured bars
- ♦ hold strip in liquid for about 20 seconds, remove the strip, shake once to remove excess water
- ♦ allow 1 min for the strip to react
- ♦ match the colour of the bars with the coded bars on the side of the pack.
- ♦ record pH_w as 1:5 soil:water suspension in Table 11
- ♦ comment on the pH_w of the soil
- ♦

(Note: these strips may also be used for wastewater or effluent)

Figure 11 pH strips

Table 11. RECORD OF pH IN TEST SOILS

Soil sample	Measured pH_w	Comment
SOIL 1		
SOIL 2		
SOIL 3		
SOIL 4		
SOIL 5		

TRANSFER pH values to Table 13

TABLE 12. INTERPRETATION OF pH_w

(Reported as pH in 1:5 soil water suspension)

pH_w value	Accessory Indicator	Condition indicated	Environment/plant interpretation
<3.5	EC > 1.4 dS m $^{-1}$	saline, acid sulphate	too acid, saline for plant roots, salinisation
	EC < 0.7 dS m $^{-1}$	non-saline, acid sulphate soils	very acid, high heavy metal availability, very high lime requirement, soil microflora changes, few plants tolerate
3.6 - 5.5	sandy texture	acid (usually organic) soils	needs lime, fertilisers, high heavy metal availability, plants require acid tolerance
	texture not sandy	acid, Al toxic soils, Mn toxic in many red soils	needs lime, fertilisers, Al tolerance in plants, decreased DOC, Fe in water
5.6 - 8.0		Normal soils, base saturated.	range suitable for growth of many plants
	Dispersive	sodic soils	soil structure problems may restrict root growth, requires gypsum
> 8.0	EC > 1.4 ds m $^{-1}$	saline, calcareous soils	saline, gypsum ineffective, contributes to poor groundwater quality, low trace element availability
	EC < 0.7 ds m $^{-1}$	alkaline, calcareous soil	High pH tolerant plants, low trace element availability, except Mo
	>1.4 ds m $^{-1}$ and / or dispersive	alkaline, sodic soils	as above for sodicity, may require acid inputs for long term amelioration

Source: Merry, R.H. (1996)

Waterlogged soils may increase in pH (become more alkaline) during waterlogging due to the chemical changes (consumption of H^+), but revert to a lower pH when aerated conditions return.

NOTE: pH may also be measured in 1:5 soil:0.01M $CaCl_2$ suspension
Analyst must report the method used to measure pH

It is usual that the pH in water is about 0.5 to 1.0 units higher than pH in 0.01M $CaCl_2$.

Transfer the class and grade for each of the parameters tested then make an assessment for suitability for use as a disposal field for domestic effluent.

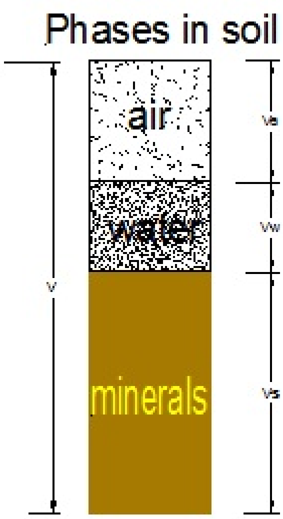
TABLE 13. SOIL SUMMARY SHEET

Soil No.	**Dispersion Class Exercise 1**	**Salinity Class Exercise 2**	**pH Exercise 3**	**Texture Grade Exercise 4**	**Permeability Demo 2**	**Suitability**
Soil 1						
Soil 2						
Soil 3						
Soil 4						
Soil 5						

Some soil properties may be ameliorated with lime, gypsum, organic matter, mineral matter.

EXERCISE 5. MEASUREMENT OF BULK DENSITY, VOID RATIO and POROSITY

Equipment: Electronic balance; assorted mineral fractions, pre-sieved; 400 mL plastic jar; 1 L water (tap water)



Purpose: Using a 400 mL jar as a known volume, determine the void ratio, porosity and bulk density, by calculation, from measurements of mass on dry material and on saturated material.

Equations:

$$\text{Bulk Density (kg/m}^3\text{)} = \frac{\text{mass of known volume (kg)}}{\text{volume (m}^3\text{)}}$$

$$\text{Void Ratio } (e) = \frac{\text{volume of voids (mL)}}{\text{volume of solids (mL)}}$$

$$\text{Porosity } (n) = \frac{\text{volume of voids (mL)}}{\text{total volume (mL)}}$$

In oven-dry material there is no water

Procedure:

Turn scales ON (scales will default to OFF after set period) RE-ZERO Display shows 0 g		
Weigh empty container and record mass	**A**	g
Remove jar from balance, fill to brim with water, RE-ZERO, re-weigh and record mass	**B**	g
Calculate volume of jar (1 mL = 1 g) (B - A)	C	mL
Remove jar, empty water back into bottle		
Fill jar with mineral fraction, bump on ground to compact material, fill to brim, RE-ZERO balance, re-weigh jar + material, record mass	**D**	g
Calculate mass of material (D - A)	E	g
Calculate bulk density of material (E in kg / C in m^3)	F	kg/m^3
Remove jar + material from balance, slowly pour water down the inside so the jar fills slowly from the bottom, excluding air as it fills the voids, gently tapping the side of the jar to displace any bubbles. Fill to brim. Note: with very fine material there may be some consolidation - ignore. RE-ZERO, re-weigh and record mass	**G**	g
Calculate volume of water added (G - D) (same as volume of voids)	H	mL
Calculate void ratio (H / (C - H))	I	
Calculate porosity (H / C)	J	%

EXERCISE 6. FIELD EXAMINATION OF SOILS

Review: The purpose of an examination of the soil profile to about 1.2 m deep is to determine the likely impediments to effluent application by identifying soil horizons, textural variation and water relationships throughout the profile.

This exercise will be conducted in the field under supervision

Equipment

Spade	Soil Auger
Water + spray pack	Soil pH test kit
Plastic sample bags, markers and tape	3 x 60 mL plastic jars
Field recording sheet (as attached)	3 x 50 mL centrifuge tubes

Procedure

Select an appropriate site, based upon location of drainfield site or other requirements (irrigation area, sample site)

Firstly describe the exact location and the soil landscape:

slope	elevation	relief
aspect	geological origin	topographic position
surface drainage	erosion	vegetative cover

Using the spade, dig a square hole about 300 mm deep and overturn the soil (this process will be demonstrated) to expose the roots and subsoil.

Using the soil auger, continue to excavate the soil, place each auger full of soil neatly along the ground to show the changing soil with increasing depth. (DO NOT spread the soil out too much or you lose perspective of the soil profile). Continue to 1.1 m deep or rock.

Using the plastic markers, determine the extent of each soil horizon and check measured depth of each.

For each horizon (three in Figure 8) describe and record:

- soil colour, mottles
- soil texture and dispersibility
- pH, EC at each horizon
- test for concretions
- rocks, roots, other identifying signs

Take samples as appropriate, accurately label bag and note depth at which sample was taken.

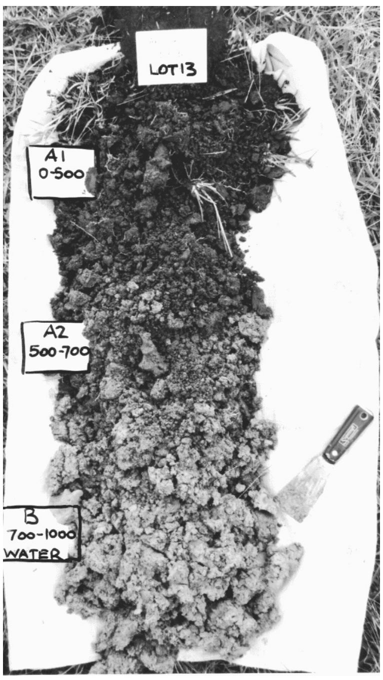


Figure 13 Soil profile layout

(NOTE: you cannot determine soil structure from an augered sample)

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SOIL SURVEY SHEET

Landscape (description) Site No.........................

Geology		Surface drainage	
Vegetation		Internal drainage	
Aspect		Groundwater	
Slope (%)			

Buffer distances (all distances in metres, upslope or downslope)

Sketch house on the lot	Surface water storage	Groundwater bore or well
	Other buildings	Swimming pool
	Property boundary - upslope	Property boundary - down slope

Profile Description (section numbers refer to Chapter 7 notes)

Soil horizon 6.2.1	depth (mm) from - - - to	boundary type 6.2.3	field texture 6.2.4	structure -shape, grade, size 6.2.5	pH (units) Exercise 3	EC (dS/m) Exercise 2	dominant colour - moist 6.2.6	mottles 6.2.7	dispersion Exercise 1	coarse fragments 6.2.15
top										
second										
third										

Recorder .... Date ....