ASSESSMENT OF SOILS FOR ON-SITE EFFLUENT DISPOSAL

PRACTICAL EXERCISES

Introduction

Treated domestic effluent comprises water together with a range of chemical and biological constituents. It is generally reused or disposed of by returning it to the soil. The capacity of the soil to assimilate and further treat the effluent is critical to minimising adverse environmental and public heath impacts. Effluent is held in the soil to be available for evaporation and transpiration at the surface or to pass downward through the soil profile to ultimately reach the water table. Whilst in contact with and passing through the soil, the effluent will undergo transformations, determined by the soil's physical, chemical and biological characteristics. The soil may act as a filter, a sorptive or reactive media, afford an environment for aerobic treatment and further biological treatment.

Effluent is commonly of low salinity (EC<1 dS m^{-1}) and this can exacerbate structural stability problems in some soils.

To better understand effluent/soil interaction it is important to understand the physical, chemical and biological characteristics of both the effluent and the soil. The following exercises investigate soil properties which have a bearing on effluent management in the soil environment.

Soil aggregates

When an air-dried ped (soil aggregate) is placed in low salinity water it might retain its integrity and remain stable, swell, slake (fall apart on wetting as trapped air bubbles force their way out through the soil mass and dislodge soil particles as they escape), or more completely disperse (dissociate to release fine colloids in suspension as a cloud around the ped). 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.

Figure. 1 Soil aggregates (Image: Terrain NRM)

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).

Demonstrations:

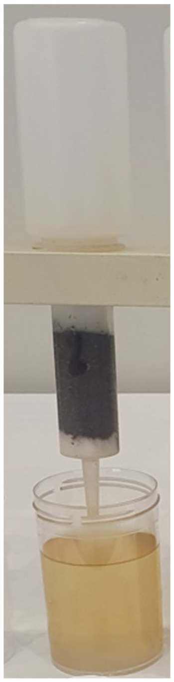
- compare the effects of clean water and wastewater upon several soils; and
- show the effects of salinity on dispersed soils.

Exercises provide practical experiences in:

- determining soil structural stability;
- measuring electrical conductivity;
- measuring soil pH; and
- describing soil texture by a field method.

DEMONSTRATION 1

EFFECTS OF WASTEWATER ON SOIL PERMEABILITY



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

Laundry detergents may provide a high relative concentration of sodium salts (SAR) as well as high pH; both properties which enhance dispersion in soil.

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. 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 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.

Figure 2. Soil column set-up

Table 1. Effects of water chemistry on soil permeability

Start time:		**Finish time:**		**Time elapsed:**	
	Volume of leachate (mL)		**Colour of leachate**		**Suitability for on-site disposal (Rank)**
	Clean water	**Laundry water**	**Clean water**	**Laundry water**	
1					
2					
3					
4					

Points to consider:

- Differences in permeability reflect effects of effluent chemistry;
- Differences in leachate colour reveal particulate (colloid) movement; and
- Differences between soils reflect individual soil properties.

DEMONSTRATION 2

EFFECTS OF INCREASING SALINITY ON DISPERSION

Dispersion is caused by colloidal clay particles in the soil repelling one another.

Clay particles are naturally negatively (-ve) charged. Positive (+ve) ions in the soil are electrostatically attracted to the negative clay surface and neutralise the charge in the clay. Where sodium ions (Na+) dominate these cation exchange sites and the soils are wetted, a thick layer or shell of positive charges surrounds the clay particles and they repel, causing the soil to disperse. Cations in solution in the soil affect the thickness of the shell. Cations with greater numbers of positive charges (Ca^{2+}, Mg^{2+}, Al^{3+} etc) neutralise more negative charges on the clay, causing the shell to become thinner and allowing the clay particles to come together and flocculate. The saltier the soil solution, the more readily a dispersive soil will flocculate.

Whilst aluminium is the most effective flocculating agent (and is used in drinking water treatment), calcium can be used to avoid the toxic effects of aluminium. Calcium salts (gypsum, lime and dolomite) provide essential plant macro-nutrients and a cost-effective means of ameliorating dispersive soils.

Sodic soils are typically highly dispersive and have a high concentration of exchangeable Na^+, therefore much of the negative charge on the clay is neutralised by Na^+ creating a thick positively charged shell that may prevent clay particles from flocculating.

Effluent, too, introduces significant amounts of Na^+ to the soil and similarly can be contributory to spoil dispersion. The dispersive soil swells and dispersed particles block pore spaces in the soil, causing the soil to become waterlogged. Note also that sodium can cause flocculation at very high levels, for example when a muddy river discharges into the sea (EC 34 dS m^{-1}).

Ameliorating the effects of wastewater chemistry on dispersive soils can be replicated by demonstrating the effects of flocculation on a totally dispersed soil.

Demonstration

A small quantity (2.0 g) of dispersive soil is added to each of five jars which are then filled with deionised water. The jars are treated as follows:

- Control - nothing added
- Sodium chloride at rate of 1,000 mg Na^+ L^{-1}.
- Potassium chloride at rate of 1,000 mg K^+ L^{-1}
- Calcium chloride at rate of 1,000 mg Ca^{2+} L^{-1}
- Aluminium chloride at rate of 1,000 mg Al^{3+} L^{-1}

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

After a period, make a visual examination of the five jars and report on the turbidity of the water column. Note the clarity with which the black and white colourings of the marker strip on the jars can be seen through the water. 0 = cannot distinguish black/white; 1 = poor distinction black/white; 2 = clear distinction black/white.

Table 2. Observed effects compared with control

Treatment (salt added)	Clarity rating	Effect of added salt	Typical pH	Typical EC (dS/m)
Control			**6.60**	**0.005**
Sodium			**6.30**	**3.75**
Potassium			**6.35**	**2.80**
Calcium			**6.03**	**4.12**
Aluminium			**3.25**	**6.75**

EXERCISE 1

DETERMINATION OF SOIL DISPERSIBILITY

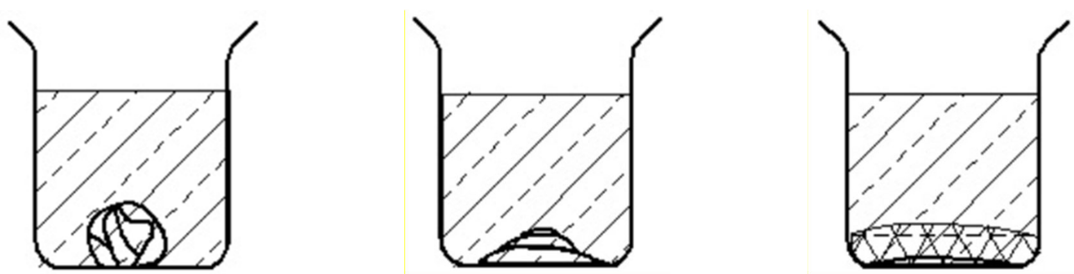
Introduction

This exercise involves the first part of the Emerson Aggregate Test to determine the suitability of the soil for effluent application.

Procedure:

As a group:

- Lay out the sheet marked Dispersibility;
- Take four Petri dishes and place them on the circles marked 1-4;
- Remove the lids;
- Two-thirds fill each Petri dish with deionised water;
- Take two or three soil peds from each of the jars numbered 1-4 and place them gently into the water in the correspondingly numbered Petri dish;
- Observe any early reaction of the peds to contact with water;
- Leave the peds undisturbed; and
- After one hour, examine the peds and refer to Figure 3.



Water stable	Slaked	Dispersed
Swell or no swell	Slumped soil mass	Cloudiness above soil mass

Figure 3. Three states of aggregate stability

Note: this is only the first part of the Emerson Aggregate Test. Emerson's original aggregate observation was made after 16 hours.

To more realistically assess the behaviour of soil under effluent application, it would be preferable to examine the dispersibility of the soil in the actual effluent. Water of SAR 5 with an EC less than 1 dS m^{-1} can be used to simulate domestic wastewater.

Observations

- Water stable (soil ped maintains same shape, but may swell);
- Slaking (soil ped collapses into a pile of separate soil particles); or
- Dispersion (clay particles cloud the water around the ped).

EXERCISES 2 & 3

DETERMINATION OF ELECTRICAL CONDUCTIVITY AND SOIL pH

Introduction

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

Electrical conductivity (EC)

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 and the water conducts an electric current more easily. EC has 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, also known as soil 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 4

4 x 50-mL centrifuge tubes with lids

1 Hanna pH & EC meter, pre-calibrated

1 pack of pH test strips

1 plastic spoon

4 x 60 mL plastic jars without lids

Procedure:

As a group:

- Lay out the sheet marked EC and pH;
- Place four 60 mL jars, with lids removed, on each of the circles marked 1-4 and stand a 50 mL centrifuge tube in each jar;
- Fill the centrifuge tubes with corresponding numbered soil up to the 7.5 mL mark;
- Fill the centrifuge tubes to the 45 mL mark with deionised water, replace cap (this approximately represents a 1:5 soil:water suspension); and
- Shake each tube for about 10 seconds, once every 10 min for 30 min.

Note: New Zealand 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

Introduction

Classification of soil by texture refers to the relative proportions of sand, silt and clay present in the soil. 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 and sands	**4**	Clay loams
2	Sandy loams	**5**	Light clays
3	Loams	**6**	Medium to Heavy clays

Equipment:

Each group will have four soils (1-4), 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 (bolus) 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 there is no apparent change in the feel of the soil. This should usually take about two minutes or more. Note: Should too much water be added, add some more soil. If the bolus dries out, add some more water;
- Note the feel of the soil (sandy, silty, smooth, plastic,) while you are kneading it;
- When the bolus is well formed, feed the soil between your thumb and forefinger 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 Table 5;
- Record your findings in Table 4; and
- Repeat the exercise for each of the soil samples.

The range of soils has been chosen to provide a “feel” for a variety of soil textural classes. Determine the texture of each sample provided. It is recommended that all members of the group work concurrently on the same soil, to enable them to compare and discuss each soil.

Figure 4. Forming a ribbon from the bolus

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

- Sand particles are equidimensional, clearly visible to the naked eye, feel gritty and when dry, run through the fingers.
- Silt particles are also equidimensional, but not visible to the naked eye. They roll between the thumb and forefinger. When dry, they are easily brushed off the hands.
- Clay particles are smaller again, slide between the thumb and forefinger and fill pores in the skin. They are greasy and sticky when wet, hard when dry and have to be washed or scraped off hands (or boots).

- Loam is a relatively even mixture of sand, silt and clay grains and feels spongy when worked into a bolus.

Once you have worked the soil into a bolus, describe the soil as SAND, LOAM or CLAY

Table 4. Record of field texture determination

Soil sample	Grittiness	Stickiness	Plasticity	Stain	Ribbon Length (mm)	Field Texture Grade
1						
2						
3						
4						

Record Grittiness and Stickiness as; NONE, SLIGHT, MODERATE, VERY OR EXTREMELY

Record Plasticity and Stain as YES or NO

Grittiness - sand grains impart a gritty feeling to the soil. Sand grains may be visible or may be heard rubbing against one another as you work the bolus.

Stickiness - the adhesive forces between the soil and your 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).

Transfer Field Texture Grade from Table 4 to Table 13.

Table 5. Texture Grade

	Field Texture Grade		Behaviour of moist bolus	Ribbon (mm)	Approx. clay content %
Cat 1	**S**	Sand	Coherence nil to very slight, cannot be moulded; sand grains of medium size; single sand grains adhere to fingers.	Nil	<5%
	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; will form minimal ribbon of 5-15 mm; discolours fingers with clay stain.	5 - 15	5-10%
Cat 2	**SL**	Sandy loam	Bolus coherent but very sandy to touch; will form ribbon of 15-25 mm; dominant sand grains are of medium size and are readily visible.	15 - 25	10-20%
	FSL	Fine sandy loam	Bolus coherent; fine sand can be felt and heard when manipulated; will form ribbon; sand grains are clearly visible under a x10 hand lens.	13 - 25	10-20%
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 the touch if much organic matter present; will form ribbon of about 25 mm.	25	about 25%
	ZL	Silty loam	Coherent bolus; very smooth to often silky when manipulated; will form ribbon of about 25 mm.	25	about 25% and with silt 25% or more
Cat 4	**SCL**	Sandy clay loam	Strongly coherent bolus, sandy to touch; medium-sized sand grains visible in finer matrix; will form ribbon of 25-40 mm.	25 - 40	20-30%
	CL	Clay loam	Coherent plastic bolus, smooth to manipulate; will form ribbon of 40-50 mm.	40 - 50	30-35%
	ZCL	Silty clay loam	Coherent smooth bolus, plastic and often silky to the touch; will form ribbon of 40-50 mm.	40 - 50	30-35% and with silt 25% or more
	FSCL	Fine sandy clay loam	Coherent plastic bolus; fine sand can be felt and heard when manipulated.	40 - 50	30-35%
	SC	Sandy clay	Plastic bolus; fine to medium sand can be seen, felt or heard in clayey matrix.	50 - 75	35-40%
Cat 5	**SiC**	Silty clay	Plastic bolus; smooth and silky to manipulate.	50 - 75	30-40% and with silt 25% or more
	LC	Light clay	Plastic bolus; smooth to touch; slight resistance to shearing between thumb and forefinger; will form ribbon of 50-75 mm.	50 - 75	35-40%
	LMC	Light medium clay	Plastic bolus; smooth to touch; slight to moderate resistance to ribboning shear; will form ribbon of about 75 mm.	75	40-45%
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; will form ribbon of 75 mm or more.	>75	45-55%
	HC	Heavy clay	Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; has firm resistance to ribboning shear; will form ribbon of 75 mm or more.	>75	50% or more

Source: National Committee on Soil and Terrain (2009). Australian Soil and Land Survey Field Handbook. Third Edition. CSIRO Publishing, 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.

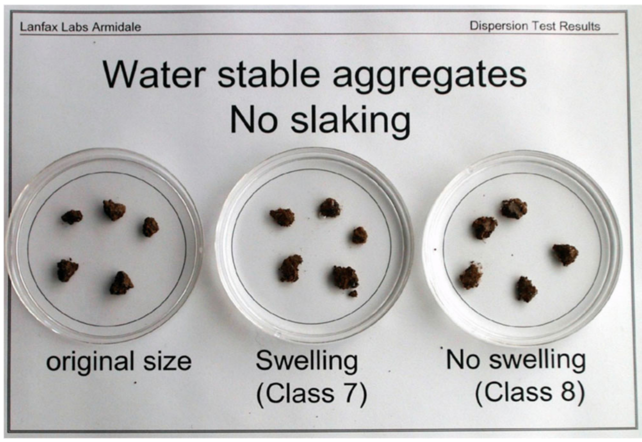


Figure 5. Water stable aggregates

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 6. Various degrees of slaking

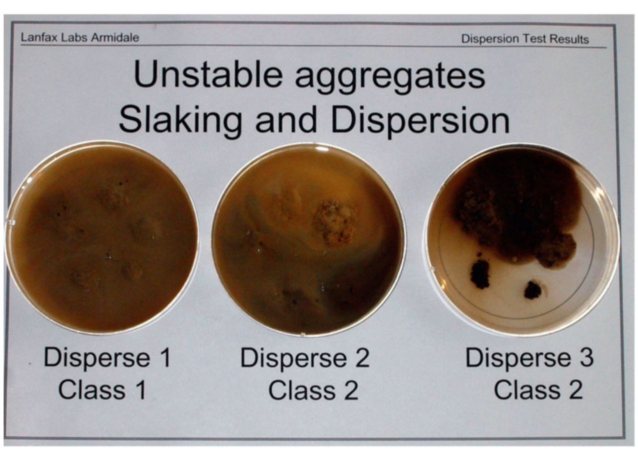


Figure 7. Partial and complete dispersion

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.

MODIFIED EMERSON AGGREGATE TEST

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 78-104.

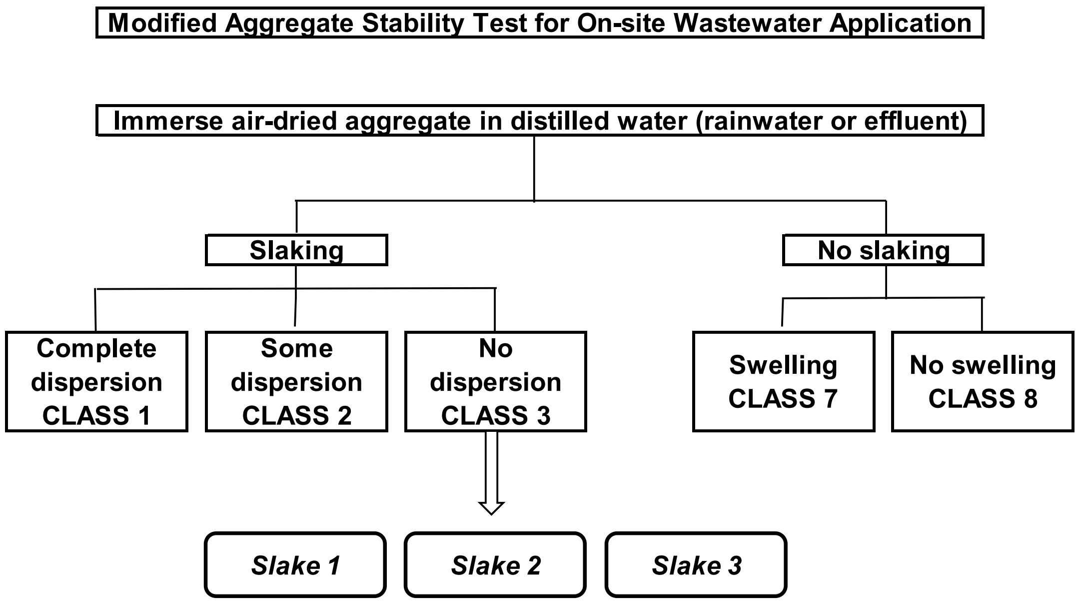


Figure 8. Modified Emerson Aggregate test for on-site wastewater application

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 sample	Complete dispersion CLASS 1	Some dispersion CLASS 2	No dispersion CLASS 3 *Slake 1, 2 or 3 (3/1, 3/2, 3/3)*	Water stable Swelling CLASS 7	Water stable No swelling CLASS 8
1					
2					
3					
4					

Transfer Dispersion class from Table 6 to Table 13.

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 as the amended test described 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'.

Soils which are identified as dispersive should be considered as Category 6 soils.

Table 7. Soil aggregate stability

Emerson Aggregate Test conducted with distilled water. For effluent disposal purposes use effluent.

Emerson 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 the bottom of the dish. 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 by laboratory testing.	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 by laboratory testing.	Poor, some loss of permeability, requires amelioration	
3	*No dispersion of air-dried ped* *Complete or partial dispersion of remoulded ped*	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, Contains calcite or gypsum, Good permeability.	Ideal, not affected by digging	
5	*Dispersion after shaking in 1:5 suspension after 5 minutes*	Remoulded soil: no dispersion under normal agricultural practices because water content is outside field capacity. Usually high in Ca, Mg. Good permeability.	Ideal	
6	*1:5 suspension flocculation after 5 minutes*	After shaking in 1:5 suspension begins to flocculate within 5 minutes. Complete flocculation. Will usually have good soil structure and high permeability.	Ideal, good permeability	
7	No slaking, some swelling	Peds remain coherent and 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

(i.e. 3/1 = little slaking, 3/2 = partially (half) slaked, and 3/3 = 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 for 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

ELECTICAL CONDUCTIVITY

Procedure:

AFTER 30 minutes, for each soil

- Remove cap from tube;
- Check meter is set to record EC in uS/cm (see screen);
- Pour liquid into 60 mL plastic container, dip conductivity probe into the solution, ensure that the liquid covers the probe;
- Record meter reading, including the units uS/cm;
- If over-scale, record as >2,000 uS/cm (meter reads 1 on LHS when over scale);
- Rinse probe with deionised water before making next reading;
- Record all results in Table 8;
- Convert all results to deciSiemens per metre by dividing by 1,000, and
- Refer to Table 9 (Australia) or Table 10 (New Zealand) to determine the salinity hazard.

Once testing is complete, please rinse the EC meter and switch OFF

Figure 9. EC Meter

Table 8. Record of EC testing

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

Soil Sample	EC reading (meter reading) ($\mu S\ cm^{-1}$)	EC as $dS\ m^{-1}$ (EC reading/1000)	Salinity hazard (Select from Table 9 or 10)
1			
2			
3			
4			

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

Once you have determined the Salinity hazard class using Table 9 (Australia) or Table 10 (New Zealand) add the values to the final column of Table 8 and transfer the data 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. Interpretation of EC (Australia)

EC of 1:5 soil/water extract (dS m^{-1})					Salinity hazard	Effect on plant growth	Salinity hazard class
Sand loamy sand	Loam	Sandy clay loam	Light clay	Heavy clay			
<0.15	<0.17	<0.25	<0.30	<0.40	Non-saline	Negligible effect	1
0-16-0.30	0.18-0.35	0.26-0.45	0.31-0.60	0.41-0.80	Slightly saline	Very sensitive crops affected	2
0.31-0.60	0.36-0.75	0.46-0.90	0.61-1.15	0.81-1.60	Moderately saline	Many crops affected	3
0.61-1.20	0.76-1.50	0.91-1.75	1.16-2.30	1.61-3.20	Very saline	Salt tolerant plants grow	4
>1.20	>1.50	>1.75	>2.30	>3.20	Highly saline	Few salt tolerant plants grow	5

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

How to use Table 9.

For each soil:

- Select the column which best describes the soil textural class recorded in Table 4;
- Move down the column until you find the range within which the EC (in dSm^{-1}) for the soil lies; and
- Move along the row to the right to determine the Salinity hazard class and note the effect on plant growth.

Once you have determined the Salinity hazard class for each soil using Table 9 (Australia) add the values to the final column of Table 8 and transfer the data to Table 13.

Conversion of EC1:5 to EC_{SE} (EC_{SE} is the same as ECe) (Charman & Murphy, 2000):

clay loam: multiply EC1:5 x 8.6 to convert to EC_{SE}

light clay: multiply EC1:5 x 7.5 to convert to EC_{SE}

medium clay: multiply EC1:5 x 5.8 to convert to EC_{SE}

Example:

if the EC1:5 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}

Table 10. Conductivity, Rating and Soluble Salts (New Zealand)

Conductivity (dS m^{-1})	Rating	% Salts
>2.0	Very high	>0.7
0.8-2.0	High	0.3-0.7
0.4-0.8	Medium	0.15-0.3
0.15-0.4	Low	0.05-0.15
<0.12	Very low	<0.02

(after Blakemore et al., 1987, table cited in Milne et al., 1987)

Once you have determined the Rating (Salinity hazard class) for each soil using Table 10 (New Zealand) note the class the final column of Table 8 and transfer the data to Table 13.

RESULTS: EXERCISE 3

SOIL pH MEASUREMENT

Procedure:

For each soil, 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 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 minute 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, and
- Comment on the pH_w of the soil.

Note: the same pH strips may also be used for wastewater or effluent.

Figure 10. pH strips

Table 11. Record of pH in soils

Soil sample	Measure pH_w	Comment
1		
2		
3		
4		

Transfer pH values to Table 13.

Table 12. Interpretation of pH_w

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

pHw value	Accessory indicator	Condition indicated	Environment/plant interpretation
<3.5	EC>1.4 dSm^{-1}	Saline, acid sulphate	Too acid, saline for plant roots, salinisation
	EC>0.7 dSm^{-1}	Non-saline, acid sulphate	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) soil	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 dissolved organic carbon (DOC), Fe in water
5.6-8.0		Normal soils, base saturated	Range suitable for growth of many plants
	Dispersive	Sodic soil	Soil structure problems may restrict root growth, requires gypsum
>8.0	EC>1.4 dSm^{-1}	Saline, calcareous soil	Saline, gypsum ineffective, contributes to poor groundwater quality, low trace element availability
	EC>0.7 dSm^{-1}	Alkaline, calcareous soil	High pH tolerant plants, low trace element availability, except Mo
	EC>1.4 dSm^{-1} and/or dispersive	Alkaline, sodic soil	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. Summary sheet

Soil sample	Dispersion Class Exercise 1	Salinity Class Exercise 2	pH Exercise 3	Texture Grade Exercise 4	Permeability Demonstration 2	Suitability for effluent
1						
2						
3						
4						

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

EXERCISE 5

FIELD EXAMINATION OF SOILS

Introduction

It is important to thoroughly investigate soils to a depth of at least 0.6m beneath the point of application of effluent, to determine soil characteristics and the presence of any limiting layer which might constrain effluent application. Standards and guidelines may require or recommend an investigation depth. Assuming a typical trench depth of 0.6m, the soil profile might be undertaken to depth of 1.2m. The investigation will identify soil horizons, textural variation and soil/water relationships throughout the profile.

This exercise will be undertaken in the field as part of the Site and Soil Assessment and Design Exercise.

Equipment

Spade
Water and spray bottle
Soil pH test kit
3 x Petri dishes
3 x 50 mL centrifuge tubes
Soil Auger
Tape measure
Plastic sample bags and marker
3 x 60 mL plastic jars
Field recording sheet

Procedure

Select an appropriate site which is representative of the preferred land application system location.

Describe the exact location using GPS, or by marking on a site plan and describe the soil landscape:

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

Using the spade, dig a square hole about 300 mm deep and overturn the soil to expose the roots and subsoil. This will enable you to investigate the soil structure and the extent of root penetration into the soil profile.

Using the soil auger, continue to excavate the soil, place each auger full of soil neatly on the ground to show the changing soil with increasing depth. Try to keep your excavated soil profile in proportion to the hole depth, so as not to lose perspective of the soil profile. Continue to the required depth or refusal on rock.

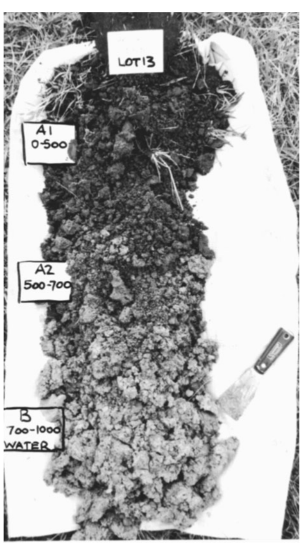


Figure 11. Soil profile layout

Determine boundaries between soil horizons and measure the depth of each.

For each horizon, describe and record:

- soil colour;
- mottles;
- soil texture;
- dispersibility;
- pH;
- EC; and
- rocks, roots, other identifying characteristics.

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

Note: it is not possible to determine soil structure from an augured sample.

SOIL SURVEY SHEET

Site: **Date:**

Landscape (description)

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

Buffer distances/setbacks (metres, upslope/downslope)

Sketch plan	Surface water storage	Groundwater bore or well
	Other buildings	Swimming pool
	Property boundary upslope	Property boundary downslope

Profile description

Soil horizon	Depth	Boundary type	Field texture	Structure	pH	EC (dSm^{-1})	Colour	Mottles	Dispersion	Course fragments
Top										
Second										
Third										

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