Soils and Effects on Effluent. What do we measure?

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Soils and the effects of effluent - what do we measure?

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INTRODUCTION:

The effects of effluent quality upon the soil may range from behaving as a clean water input to that causing serious sodicity- salinity levels in the receiving soil. It is important that before decisions are made of the soil properties to be measured (monitored), the interaction between the effluent and the soil must be understood clearly.

This section addresses some of the influences of effluent quality upon the soil; provides an outline of a demonstration of soil-effluent interaction; gives an opportunity for participants to undertake a field texture analysis and dispersion test; and finishes with the inspection of two soil pits to assess their suitability and management for effluent disposal.

TYPES OF EFFLUENT QUALITY

The effluent available for disposal may be compared to rainwater which is characterised by:

- pH about 5.5 to 6.5
- EC usually less than 20 uS cm^{-1}
- salts of low concentration,
- nutrient content extremely low (NPK)

Rainwater, as a natural part of the hydrologic cycle (rainfall -evaporation sequence), provides water essential for biological processes - plant and animal survival, growth and reproduction as well as being a natural flushing agent.

Effluent, which affects living systems, must be accounted for in the management of disposal options and in the decisions for soil - water monitoring programs. In other words - what do you measure that will indicate likely positive or negative impacts upon living systems?

The quality of the effluent should be measured in terms of:

- pH (acidity or alkalinity), pH 7 is neutral;
- EC - used as a gauge of all the ions in the solution; levels > 1 dS m^{-1} (1000 uS cm^{-1}) should be investigated further, EC is used to calculate Total Dissolved Solids (TDS)
- nutrient status
  - cations Na, K, Ca, Mg,
  - anions -nitrate, phosphate, sulphate, chloride
  - metal ions, Cu, Zn, Mn, Fe, Al
- Biochemical oxygen demand (BOD_5)
- Total Solids (TS), Total Suspended Solids (TSS)

SOIL PROPERTIES

Understanding some basic soil properties that may be influenced by the effluent quality will permit the operator to select appropriate disposal options. Some important properties include:

- soil depth and the various soil profile horizons
- soil drainage (internal and external)
- soil texture (proportions of sand, silt and clay)
- soil structure (aggregation of soil particles)
- soil chemical properties - current nutrient status
- cation exchange capacity - nutrient storage
- exchangeable sodium percentage (ESP)

EFFECTS OF EFFLUENT ON SOILS

A. Alteration of soil pH. As many nutrients depend upon a particular range of pH over which they are available for plant uptake, a shift in pH outside that range renders the nutrients less available, even though they are still in the soil. For this reason, the application of lime (to elevate pH) or sulphur (to lower pH) may be necessary.

B. Change chemical balance. The balance of nutrients within the soil is important for microbial and plant growth. The balance of N-P-K, Ca / Mg ratios, and the availability of sulphur and micronutrients must be maintained. When applying effluent, it may be necessary to alter the nutrient balance by supplementary application of particular fertilisers.

C. Increase in salinity As well as impinging upon the water table, effluents generally add significant quantities of salts to the soil environment, such as sulphates, phosphates, bicarbonates, chlorides of the cations sodium, calcium and magnesium. The total impact of these salts may increase soil salinity to extreme levels unless leaching by rainfall or clean water irrigation occurs.

Sodicity, the effects of sodium on plant and soil environments may also occur where total salinity levels are low. In water, the potential for sodicity problems is monitored as the Sodium Adsorption Ratio (SAR) and in soils as the Exchangeable Sodium Percentage (ESP).

D. Reduce hydraulic conductivity. The effects of sodium and salinity (EC) interact to improve or reduce the movement of water through the soil, that is from the surface down through the soil pores in all directions, but generally downwards in response to gravity. Effluent with a high SAR and low EC may significantly reduce the hydraulic conductivity through effects of dispersion and destruction of structural aggregates.

The addition of ameliorants (such as gypsum) to either the effluent or the soil will work to increase the EC of the soil solution and assist in reducing the negative impact of sodium on hydraulic conductivity.

Demonstration of effects of sodicity on soil hydraulic conductivity

Outline: The demonstration is designed to allow the observer to measure the negative impact of poor effluent quality (with respect to sodium) upon a range of soil types from alluvial sands to highly sodic clays.

The following terms require clarification:

Infiltration is the movement of water from the surface of the soil into the soil mass below.
Percolation is the movement of water through the soil in a vertical downwards direction in response to gravity .
Permeability is a measure of the speed at which water moves vertically downwards in the soil in response to gravity and capillary forces.
All these terms are, for convenience, reported in either metres per day or millimetres per hour.

Effluent quality

A synthesised effluent has been prepared for the purpose of the demonstration to show the effects of effluent upon a variety of soil types and the loss in hydraulic conductivity (movement of water downwards through the soil) in response to high concentrations of sodium and low EC.

Typical effluent analysis is:

pH 10.3
EC 1.9 dS m^{-1} (1900 mS cm^{-1})
SAR 12
other salts sulphates, phosphates, chlorides, carbonates, bicarbonates, hydroxides.

The water has a high SAR and a low EC, a combination which has the potential to reduce soil hydraulic conductivity.

Soil Properties

Alluvial sand - surface soil from a coastal river floodplain, dominantly sand with small amounts of clay and organic matter.

Black Earth - medium clay, clay content 40-50%, high shrink swell capacity, high fertility, pH around 6.5

Red Brown Earth - clay loam, red colour due to iron oxides, poor organic matter content, sets very hard on drying.

Krasnozem - red loam, high in iron oxides, extremely water stable aggregates, pH 5.4

Yellow solodic - medium clay, high sodium content (ESP = 12%), extremely dispersible, erodible, poor wet strength

TASK

1. Observe the arrangement of the soil tubes and the percolating liquids (clean water, effluent) and identify the relevant headings in the table below.

2. Record the time of the first observation and the volume (mL) of liquid under each respective soil column.

3. At a later time record the completion time and the new volume of liquid. Calculate the percolation rate in mL/min for comparison between samples and effluents. (Conversions to mm / hour would require measurements of the soil columns - beyond the scope of this demonstration.) Record percolation rate and comment on the variations.

Table 1. Results of soil percolation testing (disturbed cores)

Start time: .... End time: ....

Soil type	**Clean water leaching** **start**	**end** **volume in mL**	**Effluent leaching** **start**	**end** **volume in mL**	**Percolation rate mm/ min**	**Suitability for disposal**
Alluvial sand						
Black Earth						
Red Earth						
Krasnozem						
Yellow Solodic						

Comments: Make some general comments on the behaviour of the soil in response to the disposal of effluent to soils.

The measurement of soil dispersion in relation to effluent disposal

Outline: Soil dispersion is the response of soil colloids (particles generally less than 2 micron) to water (or effluent) and the behaviour of those colloids relative to others soil particles. Dispersion occurs when the forces of disruption are greater than the forces for cohesion, soil colloids display structural instability and move out into the soil solution. Dispersed particles are free to move with water as it drains through the soil, leading in extreme cases to tunnel erosion. Under non-erosive conditions, dispersion leads to physical clogging of soil pores, decreased percolation and increased in bulk density.

Loss of soil structural stability and movement of clay colloids are two important considerations for avoiding conditions favouring the increase in dispersibility

Soil properties for wastewater disposal

Dispersion Test (behaviour of air-dry aggregate in water)

As a group, take six plastic containers and half fill each with deionised water.
Take three soil peds (about 5 mm cross section) from each of the set of 6 soil peds.
Drop the peds gently into the water and place the container to one side. DO NOT disturb the container until the final measurement is made. You will need to examine the changes at the end of the period (after one hour).

(This is only the first part of the Emerson's dispersion test, the second part will be explained and demonstrated.)

Observations:

Slaking soil ped falls into a sludge type material, mostly caused by entrapped air and by swelling
Dispersion clay particles appear to cloud the water around the ped

EMERSON AGGREGATE TEST

Immerse air-dry aggregate in distilled water

b `

Slaking — No Slaking

b 9 ` — b `

complete dispersion (Class 1) | some dispersion (Class 2) | no dispersion | swelling (Class 7) | no swelling (Class 8)

\

Remould at water content equivalent to field capacity, immerse immediately in water

b `

dispersion (Class 3) | no dispersion

` `

carbonate or gypsum absent gypsum absent | carbonate or gypsum present

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make up 1:5 soil:water suspension shake 10 min, stand 5 min

b `

dispersion (Class 5) | complete flocculation (Class 6)

(Reference: Charman P.E.V. and Murphy, B.W. Eds (1991) *Soils. Their Properties and Management A Soil Conservation Handbook for New South Wales*. Sydney University Press. Sydney.)

CAUTION: Test should also be performed in effluent or irrigation water to be used on the soils under examination

Determination of Field Texture

Aim: To determine field texture of a range of soil materials.
Equipment: Each group will have four different soils (A-D) and a squeeze bottle filled with water.

Procedure: Individually take a small quantity of soil in the palm of your hand (approximately a tablespoon full), spray with water and kneed until the ball of soil just fails to stick to your fingers (similar to your days with plasticine). Continue kneading and moistening until there is no apparent change in the feel of the soil. Should too much water be added, add some more soil. Appreciate the feel of the soil (plastic, silty, smooth, sandy) while you are doing this - for a number of reasons.

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. Continue until the soil breaks away.

Compare the length of the broken ribbon with the table below.

Describe also the stickiness and the plasticity of the soil bolus as it feels during kneading.

Table 2. Field Texture Grade

Field Texture Grade		**Behaviour of moist bolus**	**Ribbon length (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%
LS	Loamy sand	slight coherence; sand grains of medium size; can be sheared between thumb and forefinger to give minimal ribbon.	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%
SL	Sandy loam	bolus coherent but very sandy to touch; will form ribbon; dominant sand grains of medium size and are readily visible	15 - 25	10% to 20%
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%
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%
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%
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% +

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

Soil Profile Description of in-situ soils

Aim: To describe two soil profiles in relation to basic soil properties and characteristics

Location: Two soil pits are located west of Trevenna shed

Equipment: Horizon markers, tape measure, soil pH test kit, Munsell Colour chart

Procedure: On the table below make notes of the easily described features of the soil profile for each of the soils. You will not be able to measure all the properties - make notes from the descriptions given by staff members.

Soil Profile Number One

Surface slope .... Aspect.................................... Surface Drainage................................

Vegetation .... Current Use of land...

Parent Material - Sedimentary

Horizon	Colour	Texture	Structure	Mottles	pH	Roots / Cracks
1						
2						
3						
4						

What other distinguishing features can you see which would allow you to recognise this soil at other locations?

What limitations/ benefits are there with respect to management for waste disposal (solids or liquids)

Soil Profile Number Two

Surface slope .... Aspect.................................... Surface Drainage................................

Vegetation .... Current Use of land...

Parent Material - Basalt material moving down slope from basalt hill (above University)

Horizon	Colour	Texture	Structure	Mottles	pH	Roots / Cracks
1						
2						
3						
4						

What other distinguishing features can you see which would allow you to recognise this soil at other locations?

What limitations/ benefits are there with respect to management for waste disposal (solids or liquids)

Glossary of terms for soil description

Soil Horizons:
O - surface layer of organic materials in various stages of decomposition

A - top layer of soil (topsoil) with a high level of organic matter, a darker colour and maximum biological activity relative to the horizons underneath.

A2 - similar to A but paler in colour, poorer in structure and less fertile, may be bleached (loss of colour).

B - layer below A, finer texture (more clay) than A, more dense and stronger colour. Strong development because of accumulation of silicate clays, and /or iron, aluminium, organic material leached from above.

C- weathered materials below B, unaffected by biological processes.

Horizon boundaries
The boundaries between the horizons may be described as:
sharp - less than 20 mm wide
clear - 20 to 50 mm wide
gradual - 50 to 100 mm wide
diffuse - more than 100 mm wide
They may also be described as:
even - almost plane surface
wavy - waves up and down or forms pockets
irregular- very wavy and larger pockets
broken - a discontinuous boundary

Soil Colours
Colour may indicate major soil minerals or stages of aeration.
Pale colours - may develop from pale rocks, may be leached of darker minerals, may be anaerobic.

Dark Colours - may develop from dark rocks such as basalts, may indicate high levels of decomposing organic materials.

Bright reds - usually well aerated soil, high in iron or aluminium oxide.

Dull yellows - formed when iron rich soils have a higher water content over a period.

Grey soils - may be leached of dark minerals, low organic matter levels or may be anaerobic for long periods.

Bleached soils - usually formed by severe water logging when minerals become soluble and move out of the horizon.

Roots
The abundance and form of plant roots can indicate the density of soil material, problems with nutrient or water status, or soil management problems.

Soil Structure
The arrangement of all soil particles can be expressed as the form or shape of the individual soil aggregates.
Recognisable forms include:
crumb or granular - roughly rounded peds, usually lie loosely , may be non-porous (granules) or porous (crumb).
platy -arranged as thin horizontal plates,
prismatic - vertically oriented aggregates or pillars the edges of which are well defined flat faces, the tops are plane, level and clean cut, usually B horizon
columnar - as for prismatic with the top of the prisms rounded or domed, usually B horizon
angular blocky -aggregates arranged as blocks with six relatively flat roughly equal faces (almost a cube), corners of which are sharp (angular), common in B horizon
sub-angular blocky - as above with flat and rounded faces with limited accommodation of surrounding peds.

Structure can be further classified by its grade, the degree of development and distinctness of the peds
No peds - single grain or massive
weak - peds indistinct in undisturbed soil, when displaced breaks into fragments
moderate -peds not distinct in undisplaced soil, but in displaced more than one-third soil consists of peds
strong - peds quite distinct in undisplaced soil, when displaced more than two-thirds as entire peds.

Mottles:
More than 10% of the colour of the soil mass is of a colour different from the main colour - such as spots, blotches, streaks.

Usual colours are red, orange, brown, yellow, grey, dark, pale and indicate poorly drained soils that become seasonally wet.

Cracks
Cracks form between soil aggregates (peds) due to drying or movement of the soil mass. Cracks are important because they allow gases to diffuse, water to enter and travel long distances with little resistance or roots and soil fauna to move with ease.

Soil type
Uniform profile - texture about the same in A and B horizon

Gradational profile - texture becomes more clayey with depth
Duplex soil - where the texture of the surface horizon is noticeably different (coarser) than the clayey (finer) B horizon.