# Demonstration of effects of sodicity on soil hydraulic conductivity

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**Abstract:** Wastewater produced from domestic residences reflects a change in water chemistry derived from the use of chemicals within the household. It has been shown that an average increase of 60 mg $L^{-1}$ of sodium arises from excretion of waste products, soaps, laundry detergents and kitchen related activities. When the wastewater is disposed of by land application, either through subsurface drainfields or by surface application at any scale, the effect of sodium adsorption ratio (SAR) may limit the long term potential of the soil to maintain its natural hydraulic conductivity.

This demonstration uses water of a quality equivalent to domestic wastewater to indicate the potential loss of hydraulic conductivity through five soils, when compared with water with low sodium content. The differences between clean water and sodium rich water are pronounced in the short term. In practical applications, the loss of hydraulic conductivity will reduce the expected lifetime of the disposal area while increasing the area required to adequately dispose of the wastewater.

**Keywords:** domestic wastewater, on-site disposal, sodium adsorption ratio, hydraulic conductivity.

Demonstration performed at the conference on "Innovative Approaches to the On-site Management of Waste and Water" Southern Cross University, 26th November, 1996

**Introduction:**

The disposal of wastewater from residential areas is rarely considered in light of its chemical impact upon soil physical properties. State and local government organisations rarely monitor effluent from sewage treatment plants for water chemistry other than pH, electrical conductivity (EC), phosphorus and nitrate concentrations. While each of these components may impinge upon the quality of receiving waters, there are benefits to plants utilising those nutrients for plants where land disposal is practised.

The effects of sodium on soil structural stability, dispersive actions and subsequent loss of hydraulic conductivity have been recognised for many years but fail to arouse the interests of proponents of wastewater disposal and reuse schemes. The sodium content of wastewater (untreated) or effluent (treated) remains undiminished by primary secondary or tertiary treatment, because the sodium salts encountered in domestic wastewater are always soluble. A major problem with treatment systems is that the precipitation of calcium and magnesium salts increases the sodium adsorption ratio (SAR) and exacerbates potential soil based problems for disposal.

The most simple reduction of the sodium load in effluent is to reduce the consumption of sodium within the household. The human diet is responsible for a small part of the sodium load and reduction at this point is unlikely to be accepted as a reasonable proposal. The largest contributor to the sodium load is from fillers used in laundry products. Sodium sulphate forms as much as 40% of some laundry powders and its sole purpose is to make manufacturing a little more simple. Concentrates can be made without the filler, the question to be asked is "why are not all powders concentrated?" Further, there is an alternative to sodium salts in the form of potassium salts which do not impinge upon soil chemical or physical properties.

Attached as Figure 1 is a graph depicting a range of laundry powders and liquids and the sodium load when the product is mixed with water at the rate recommended by the manufacturer. Where water with a low electrical conductivity and a high SAR is disposed of on soil, a loss in hydraulic conductivity is likely to follow. One ameliorating action is to increase the electrical conductivity of the effluent by the addition of soluble calcium and magnesium salts.The use of gypsum is widespread in agricultural production for that purpose.

**Effluent application guidelines**

It is incorrectly reported in several government guidelines that providing the EC is low, then high SAR can be tolerated. That statement is scientifically incorrect and if followed, has the potential to destroy valuable soil environments. The author (Patterson, 1994) showed that effluent of SAR 3 and an EC below 1 dS $m^{-1}$ resulted in a significant loss of hydraulic conductivity for fine textured soils. At high SAR the results were more pronounced, particularly in surface soils.

**Sodium reduction strategies**

At the individual household level the strategy is to reduce the sodium load through the wise selection of products, particularly laundry and dishwashing detergents. Unfortunately there are few guides for such a selection and the nominated content description, as printed on the pack, is unlikely to adequately inform the consumer. The attached list can be used as a guide.

For the local government operator of sewage treatment works the impending state government load based licencing system will favour land application of effluent. The operators need to be aware of the unique impact that effluent will have on the soils of their disposal area.

The strategy open to them is for a concerted public education program to reduce sodium consumption prior to the wastewater arriving at their treatment works. Such an activity must be supported by a strict monitoring and reporting program to improve public participation. A monitoring program on the disposal area must address the amelioration of the effluent prior to application and protection of the soil resource from structural degradation.

The long term effects of disposal of sodic effluent to soil will be most pronounced and the eventual loss of suitable disposal areas will impinge upon financial budgets.

## Reference

Patterson, R. A. (1994) On-site treatment and disposal of septic tank effluent. Ph.D. thesis. University of New England. Armidale.

**Demonstration**

The demonstration is designed to allow the observer an opportunity to compare the effect of impact of poor effluent quality (with respect to sodium) and clean water (very low sodium) upon a range of soil textural classes 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 | 1.5 dS $m^{-1}$ (1500 uS $cm^{-1}$) |
| 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: ....1130 hrs 26th November, 1996, Lismore Completion time: ....1530 hrs
Elapsed time 4 hours

Record also the turbidity and the colour of the effluent as it reflects the movement of nutrients and minerals from the soil

| Soil type | Clean water leaching start volume in mL | Clean water leaching end volume in mL | Effluent leaching start volume in mL | Effluent leaching end volume in mL | Percolation rate mL/ min | Suitability for land disposal Yes or No |
|---|---|---|---|---|---|---|
| Alluvial sand | | 400 light brown leachate | | 150 black opaque leachate | 1.7 clean 0.6 effluent | Yes, with caution |
| Black Earth | | 30 straw yellow leachate | | 50 straw yellow leachate | 0.13 clean 0.2 effluent | NO, poor initial loss, very long disposal field |
| Red Earth | | 600 very light brown leachate | | 30 clear leachate | 2.5 clean 0.13 effluent | NO, rapid loss of percolation, very long disposal field |
| Krasnozem | | 600 crystal clear leachate | | 290 light brown leachate | 2.5 clean 1.2 effluent | YES, short term only |
| Yellow Solodic | | nil sample not wet through | | nil sample not wet through | nil | NO |

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

Each laundry product was mixed with rainwater at a rate recommended by the manufacturer for a full normal load of a top loading automatic washing machine. An average wash cycle consumes 200 litres of water (wash, rinse, spin, rinse and spin dry). The concentrations are related to the full wash load.

The author is currently updating the analysis of a range of laundry products and examining dishwashing detergents. The brands available in supermarkets has changed since the original study and some manufacturers have changed formulae.

Figure 1. Laundry Detergents