SALINITY - MUCH MORE THAN A RURAL ISSUE!

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ABSTRACT

Salinity, or more importantly sodicity is not limited by artificial boundaries between urban densities and rural spaciousness. Nor is salinity only an issue for major irrigation enterprises using flood irrigation systems in dry inland areas but also with greywater reuse in the urban backyard. Salinity occurs whenever we interfere with the quality of water or the natural interactions between soil and water. For urban populations the outcomes of salinity can be more severe than in rural areas, although not as immediately obvious. What we do with water to make it suitable as a potable resource, and how we use water as a transport mechanism for domestic sewage from individual homes to a centralised treatment works, all have significant impacts upon increasing salinity in receiving environments. Unfortunately, the majority of the population has no idea how their household activities affect salinity of wastewater flows. Advertising agencies have a slick twist of scientific expression and politician see pixie points from appearing environmentally sensitive, but neither adds to the ability of the people to minimise salinity issues in urban areas.

This paper examines some of the mysteries used in promoting greywater reuse, the myths in water conservation and its implication for salinity, the anti-competitive policies (rebates) that falsely favour front-loading washing machines at the expense of increasing salinity and energy consumption, and the lack of advertising regulation in identifying chemicals in common household products. Not until there is active prevention of chemicals entering the environment will salinity issue stabilise, but our aim needs to focus on salinity reduction, particularly that of sodicity.

Keywords: household chemicals, salinity, sodicity, water conservation

1 INTRODUCTION

The issue of salinity as an environmental time-bomb in rural areas is one that appears to be well publicised, but poorly understood. That salinity is always bad is mostly taken for granted, yet solutions to poor soil structure and sodicity can be treated by increasing salinity of either the soil or the irrigation water, or both. Simply measuring the soil or water salinity using electrical conductivity (EC) measurements is seriously flawed in that EC responds to all salts in solution. A salt, by definition, is a compound that dissociates in water to form positive ions (cations) and negative ions (anions). Calcium carbonate ($CaCO_3$) will dissociate to form calcium cations (Ca^{2+}) and carbonate anions (CO_3^{2-}), yet calcium ions may be important for plant nutrition and soil structural stability. Sodium chloride (NaCl - common salt) dissociates to form sodium cations (Na^+) and chloride anions (Cl^-), both of which may be detrimental to plants while the sodium may also damage soil structural stability. The outcome is that EC measurements alone tell only part of the story and identification of relative proportions of calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), aluminium (Al^{3+}) and hydrogen (H^+) is needed to determine cation exchange capacity (CEC) and exchangeable sodium percentage (ESP) of the soil, and sodium adsorption ratio (SAR) of the water. These three parameters are more important than EC alone, although together with EC and pH they provide a valuable insight into the probable performance of plants and soil structural stability. Often only EC is monitored.

In drier inland areas, calcium carbonate ($CaCO_3$) and calcium sulphate ($CaSO_4$) may crystalise at a depth determined by the evaporation in the area, their presence evidenced by white concretions at about 1 m depth. Similarly, sodium salts may concentrate in the subsoil and give rise to sodic soils with distinctive structure and behaviour properties. Sodium salts are always soluble and do not form concretions that are visible to the human eye and unless structural morphology is recognised, sodic soils may go unrecognized by engineers and builders in the excavation of footings for buildings.

Initially, this paper needs to address the assessment criteria for saline and sodic soils as generally accepted in Australian soil science.

If EC, as a measure of the effects of salts on soil is flawed because it cannot discriminate between "good" ions and "bad" ions, then ESP of the soil offers a more reliable assessment of potential soil structural problems, which together with EC can be used to judge the effect of added irrigation waters (or greywater). Of the added water, SAR and EC suggest potential effects and indicate when irrigation waters may be detrimental to soil structural stability. We will see that it is not only the salinity of the soil or irrigation water that is critical to sound irrigation practices, but also soil ESP and water SAR of the water. These combinations apply equally to rural irrigation as for urban greywater disposal.

On coastal soils, significant weathering over eons has leached much of the highly soluble sodium salts deep into the profile and sodicity is not as obvious, although the sodium remains in the deeper profile. On sandy soils, sodium in greywater is significant to plant survival but irrelevant for soil structural stability. On clay soils, the sodium may have a detrimental impact on the soil as well as the plants.

The rural salinity issue is significant in the ability for the nation to feed itself and maintain an appropriate environment for future generations to meet their social, economic and environmental requirements. This paper will concentrate on the impropriety of current wastewater management to address the salinity and sodicity issues at the urban and metropolitan interface.

2 ENCROACHING RURAL SALINITY

In rural areas where salinity bites into the productivity of the agricultural or pastoral enterprise, the sneaking frontline of the saline scald may often been masked by other changes to the vegetation or grazing pattern. In Uralla, in Northern NSW, there are saline areas that are sought out by sheep and cattle that gnaw at the soil to consume the salt. In most cases it is a sodium salt (sodium bicarbonate or sodium sulphate) that animals seek out. These saline-sodic scalds may occur midslope rather than lower in the landscape, and pasture composition becomes less productive. Clearing the landscape of its trees is partly to blame, although cause and effect are often complex relationships we do not yet understand.

Figure 1 Dispersion of subsoil in Singleton area

In the Central West of NSW, saline areas in the peri-urban subdivisions around towns like Dubbo, Forbes and Lake Cargellico are obvious as expanses of white powder on a barren patch in low lying areas. Whether this scald arises from evaporation of stormwater laden with salt or groundwater bringing salt to the surface is not always easy to detect. Correcting the problem often evades the best plans as the problem often emanates from distant sources. An example of increasing salinity in a natural waterway arises because of significant over-irrigation of larger urban lots along the stream's drainage lines. The problem then affects downstream users and poor vegetation along the stream exacerbates erosion of the soil when stormwater flows. The ever increases peri-urban fringe with reticulated water at very low cost can lead to environmental degradation that may take years to surface, yet be impossible to reverse. That reticulated water itself may exacerbate salinity issues because of its inherent and increased salinity (through water treatment) is often overlooked.

In the surrounding agricultural lands, farmers are experimenting with novel ideas and developing machinery to reclaim sodic soils.

Figure 2 Mulboard ploughing

In other areas, dramatic engineering practices are employed to restructure soils as shown in Figure 2. Here the soil profile is being inverted to bring calcium rich clays to the surface to overcome the effects of sodium. These soils will then be furrowed and irrigated for cotton. It is only the significant returns from cotton that permit such extreme amelioration. At the urban level, such practices are impossible and other ameliorants must be found.

3 SIMPLE IDENTIFICATION OF SODICITY

While soils may be saline and sodic or saline and non-sodic, it is important that landowners (rural and urban) understand the simple demonstration of sodicity as portrayed by the Emerson Aggregate Test (Emerson, 1967). Air-dry peds are placed in rainwater (distilled water) and the resulting configuration of the soil is observed. The ideal soil ped remains intact or may swell, soils low in organic matter may slake (slump into a mass that does not resemble the original ped), or the soil ped may slump and then the individual particles separate and disperse into the water as shown in Figure 3. Soils which reflect this behaviour issue a stern warning of possible and probable structural problems.

Figure 3 Dispersion effects when sodic peds placed in distilled water

A further problem that sodic soils present where sporting fields or parklands are irrigated with unsuitable water is that soil permeability may be reduced. Experienced irrigators consider the SAR and EC of the water with the ESP of the soil. Ignoring the combination of salinity with sodicity of both the soil and the water is inviting plant and soil problems.

4 URBAN CALAMITY

The white scourge of the west does not have boundaries. Ancient soils high in sodium can be found around and within urban areas, yet are not recognised for their potential contribution for infrastructure decay. Engineers are not always alert to the obvious signs of sodicity in subsoils and increased bulk density is often taken as an engineering benefit.

Increasing irrigation of lawns and gardens, either individual lots or community areas, may mobilise salt from higher landscape positions and lead to elevated groundwater that brings salt up from deep soil horizons, all the same reasons they arise in rural areas. As rising damp is recognised for bringing water, that water may also transport salts that remain long after the water has evaporated. Over decades, the salt may accumulate to form crystals on the surface where it dries and as crystals grow, bricks and mortar crumble and footings become unstable.

Figure 4 shows salt crystals in the basement of the Royal Hotel at Forbes, once the site of the gold exchange that is now a damp and musty basement. Lime mortar has fallen from the bonds and without treatment will lead to unstable footings. This expression of crystallised salt is seen around the outside of the hotel, even along the main street frontage and in many other buildings in the town.

Figure 4 Salt crystal in basement wall - Royal Hotel Forbes

In Forbes, the lower areas around the town suffer from rising water tables and increased surface saline scalding, perhaps from excess irrigation of home gardens in the elevated regions of the town. The landscaping of the local lagoons may be maintaining high water tables with resulting surfacing of saline waters. So what were once rural issues are now recognised as having urban equivalents. Salt amelioration and revegetation require investment of capital and on-going maintenance to halt the progress and efforts to reverse the scalds are thwarted by seasonal conditions. A recent paper by Hardie (2007) reported on serious sodic instability problems in Hobart.

5 GREYWATER AND SODICITY

5.1 Urban examples of salinity and sodicity

The current interest in greywater reuse in suburban and peri-urban areas is driven by the need to conserve drinking water as politicians believe the contribution of individuals may be cumulative with positive outcomes. The expectation that savings of 20 kL per home in Sydney by reusing greywater without understanding the consequences of the chemistry of the greywater is misguided and has potential for environmental damage. That greywater is innocuous except for bacteria could not be further from reality. While bacteria, particularly faecal coliforms, may pose a threat to public health, the remedy is seen as either chlorination or subsoil dispersal. The environmental effects of chlorine on soil are mostly ignored as irrelevant, the more serious impact of the greywater chemistry on the soil is even more remote from serious thought.

Phosphorus in laundry detergents and household cleaners is portrayed as an environmental catastrophe because of its linkage with *Cyanobacteria* blooms in river systems. While that linkage is real, phosphorus is a valuable ‘builder’ to isolate Ca^{2+} and Mg^{2+} in hard water and for hard water areas, must be substituted by another efficient builder. Phosphorus is an essential plant nutrient and except for sandy soils or in riparian zones, phosphorus can be utilised by vegetation. An urban myth is that phosphorus “kills” native plants. It is more likely the sodium in detergents kills “natives” because they have a lower tolerance to sodium than the nutrient phosphorus. Therefore, the phosphorus debate tracks into the sodium debate.

Where the reticulated water is ‘soft’, a builder is required in only minute amounts. Smaller amounts of detergent can be effective when rainwater or ‘soft’ reticulated water is used for washing, a point that is lost in most of the detergent advertising. However, sodium enters the equation because the salts used in detergents are dominated by sodium salts – salts that are always and forever highly soluble.

5.2 Sodicity and municipal water reuse

Sodium exists in urban water supplies because sodium salts are used in the treatment of potable water and to increase the total alkalinity of the water to prevent dissolution of the infrastructure. Sodium also comes from the raw water. Therefore some municipal water supplies have elevated levels of sodium as well as calcium and magnesium. The residual calcium and magnesium influence the amount of laundry detergent required for an effective wash. Figure 5 shows SAR of 21 coastal and 44 inland urban supplies. SAR of rainwater is less than 1. It is clear that SAR is lower in coastal supplies with most less than critical SAR 5.

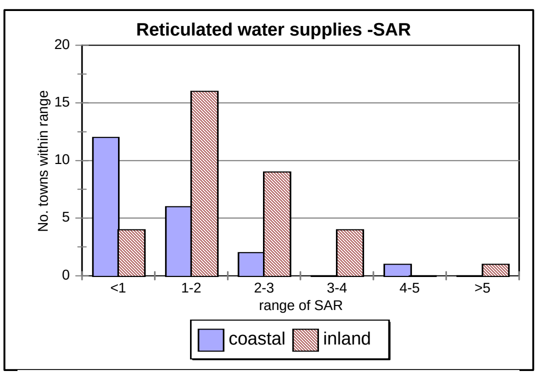

Figure 4 SAR for coastal and inland supplies

6 GREYWATER AND SALINITY

6.1 Household activities

Homeowners are encouraged to reuse greywater as a means of saving drinking water supplies and inducements range from subsidies on greywater treatment systems to television infomercials in prime viewing. While politicians advocate wide scale reuse of greywater as environmentally sound, legislation restricts the simple tasks because discharging greywater outside the sewerage system is a “prescribed activity” under the current NSW Local Government (General) Regulation 2005. That means that irrespective of how the reuse will be operated, the activity requires prior approval unless it complies with prescribed guidelines. In a way, that makes a nonsense of intermittent use of greywater by any method other than bucketing water onto the garden. An extra level of compliance that is often obscure to the average homeowner, simply means that some people will act contrary to the law and many more will simply not bother. And how do the politicians address this complexity between their desires and regulation – ignore it!

Greywater is that water generated from the bathroom and laundry that is suitable for redirection to the garden. Simple bucket management is legal, while all other methods of transferring water to the garden or lawn require compliance with several codes and guidelines and often an application to Council. My real concern is that the environmental implications of any method of discharge of greywater to land have been avoided in most of the guidelines and writings of the various departments. While they address the need to reduce salts, they also advocate water conservation.

6.2 Water conservation and greywater reuse

There is a contradiction between the general household's chemical use and water conservation. While lower water use may have sound reasoning, unless there is a reduction in the amount of chemicals used, greywater simply increases in salinity and sodicity and the reduced volume of water makes spreading the greywater over a large area extremely difficult. Take for example a shower of 6 min. at a rate of 12 L/min. and the use of hair shampoo and bath soap. Reducing the shower activity to 4 min. at 9 L/min. may save 50% water, the same use of chemicals will double the salinity and increase the pH. The greatest source of reduced water volume is in the choice of front loading washing machines compared with the more popular top loading washing machine, but there's more to the story.

6.3 Washing machines

Until the introduction of the Water Efficiency Labelling and Standards (WELS) Scheme (www.waterrating.gov.au) at the federal level and complemented in each state, there was no standard for rinse performance. The Standard AS/NZS 2040.2:2005 states that "*Without a rinse performance requirement higher water efficiency rating could be achieved by reducing rinse performance levels that may not meet the needs of washing machine users*". There is now a requirement that rinse performance is measured and reported.

Table 1. Performance of washing machines

Washing Machine Brand & Model	Type	Capacity	Dirt removal	Rinse score	average wash+rinse	Water used	normal cycle	Capital cost
		kg	%	%	%	L	minutes	$
Up to 5.5 kg								
Miele Novotronic W502	Front	5.5	84	76	80	51	117	1699
Fisher & Paykel MW512	Top	5.5	79	90	85	132	44	749
Fisher & Paykel GW512	Top	5.5	77	90	84	131	45	859
6 kg to 7 kg								
Haier HWM1260K	Front	6	75	43	59	41	95	749
Miele Honeycomb Care W1213	Front	6.5	73	59	66	54	43	2999
Bosch WAE26470AU Maxx	Front	7	73	76	75	69	72	1499
Westinghouse LT609SA Complete Care	Top	6	71	84	78	116	44	799
Fisher & Paykel GW612	Top	6.5	83	91	87	157	47	995
LG WF-T656 Turbodrum	Top	6.5	81	87	84	153	67	936
Fisher & Paykel Intuitive Eco IW712	Top	7	83	89	86	154	52	1149
7.5 kg or larger								
LG Inverter WD-1238C	Front	7.5	78	64	71	67	87	1249
Samsung Silver Nano J1455AV	Front	7.5	80	43	62	54	131	1199
Electrolux Ultra Silencer EWF1495	Front	8	82	80	81	73	108	1689
Simpson Eziset 750 22S750L	Top	7.5	69	90	80	180	56	1179
Fisher & Paykel Intuitive Eco IW812	Top	8	80	89	85	179	55	949
Simpson Eziset 800 22S800L	Top	8	60	88	74	182	56	1499
Fisher & Paykel Aquasmart WL80T65CW1	Top	8	81	74	78	76	58	899
Haier HWM90DD	Top	9	85	51	68	125	95	1199

Source data: www.choice.com.au

The rinse performance of 18 machines as tested by Choice (2007) showed that the front loaders did not perform any better than top loaders in the wash and rinse performance as shown in Table 1. It is only when water use enters the overall rating that front loaders come to the fore. In the cost of water saved, this is small in comparison with the increased running time and capital cost of equipment.

Rebates that favour only four-star WELS rated washing machines are misdirecting government funds and considerable private finances into addressing only the water shortage but magnifying the potential water quality and energy issues. Recent rebates by NSW Government on 20,000 washing machines (DEUS, 2006) amount to $3 million government subsidy, up to $30 million private expenditure for the potential annual saving of $0.4 million in water at current cost. That the increase in front loaders and greywater reuse will exacerbate urban salinity and sodicity issues is neglected. These salinity issues also affect municipal sewage treatment where the effluent is reused in schemes such as Rouse Hill.

While WELS certified front loaders mostly meet the four-star rating (74 out of 84) compared with only one out of 66 top loaders, the quantity of detergent for many is the same as for top loaders, while others are about 50% of the top loader rate, yet the wash water is up to 30% of the top loader water load. Interestingly, it is almost impossible to obtain data on the various volumes used in each of the wash/rinse/spin stages for any of the washing machines. Whether this is 'commercial-in-confidence' or means of hiding performance data is difficult to ascertain.

6.4 Laundry detergent use

Two methods of calculating the potential impact of washing water on plants and soil are available. One is to measure the EC of the 'wash only' water while the second is to measure the EC of the total cycle volume. Because of differences in wash, rinse and spin performance and the various powders available (in excess of 80 readily available brands) it has not been possible to measure rinse water quality. Recent measurements of wash only with 35 powders in front loaders and 35 powders in top loaders revealed the potentially higher salinity hazard from powders in front loaders. While overall load must be considered, as for irrigation water for agriculture, the EC of the irrigation water, together with SAR and pH are critical determinants in application rates and effects upon plants and soil.

Figure 5 shows the range of powder detergents within each band of EC for the wash only. It is clear that products can be selected for both front loaders and top loaders that have low EC values, but there are more products for front loaders with high EC. In many respects the high EC may lift the critical electrolyte concentration sufficiently high to overcome the effects of high SAR. Unfortunately, the high EC is usually associated with sodium that may have detrimental effect upon the soil when leached with rainwater or municipal water.

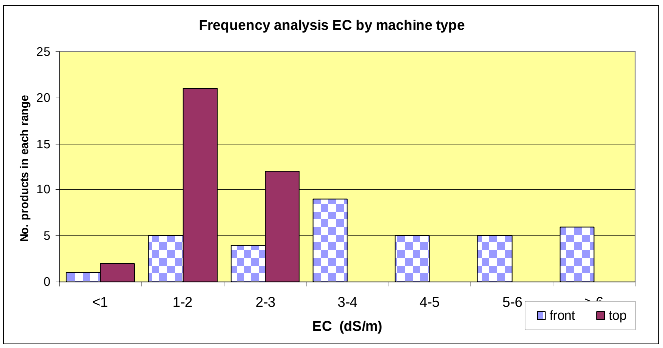

Figure 5. EC of wash only by machine type

When the wash water is analysed for sodium concentration and sorted by machine type, the lesser volume in the front loader results in many of the detergents having a very high sodium concentration as shown in Figure 6. As this value is used with the concentration of Ca^{2+} and Mg^{2+} in the water (mostly from water source), the SAR values become very high and the warning of potential soil structural stability rings loud.

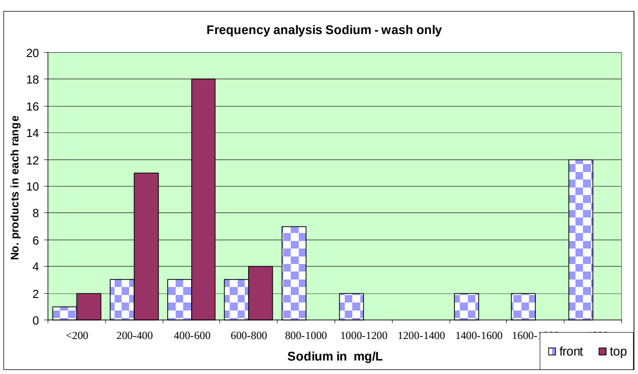

Figure 6. Sodium concentration in wash by machine type

The SAR for the wash water depends upon the input water and that is highly variable across the state as suggested in Section 5.2. Sydney Water has only low levels of Ca^{2+} (15-20 mg/L) and Mg^{2+} (5 mg/L), there is no ameliorating influence on the Na^+ by the water (Sydney Water,2005)

Where high SAR/high EC greywater is discharged to land, there is no immediate threat of soil. Structural decay will occur under rain when low EC water impinges upon the Na^+ on the exchange sites on the clay soils to induce dispersion.

6.5 Amelioration of greywater areas

Salinity and sodicity are issues that arise from uncontrolled and poorly managed discharge of greywater from domestic premises onto their own land, yet the cumulative effects of small lots discharging up to 400 L per day are likely to lead to environmental problems. Salinity from greywater alone may not generate the soil salinity likely to lead to engineering problems but the increased sodium may require amelioration with salts that will further increase salinity. The effects of sodium are ameliorated with either lime ($CaCO_3$) or gypsum ($CaSO_4$) and both these work by increasing the calcium in the soil to displace the sodium from the cation exchange sites and allow for their leaching under rainfall. Without amelioration, rain is more damaging than continued application of greywater.

The concern for urban salinity is that the problems of greywater quality alone, or in combination with ameliorants may not be recognised sufficiently early to allow adequate management. The complexity arises from many urban lots discharging greywater onto small areas. Where municipal water is used for irrigation, increased concentration in sewage discharges is an issue that must be addressed.

6.6 Household chemical labelling

It is clear that the labelling of the laundry detergents has very little connection to the potential environmental damage that washing machines discharges may have on the soil or plants. Where laundries discharge to sewer the consequences of chemical interactions are low, unless the municipal plant reuses the water for irrigation. Manufacturers are entitled to make whatever concoction of chemicals they wish and promote their products as "biodegradable" when the only degradable chemicals are the surfactants, perfume and packaging. Inorganic chemicals cannot be encompassed under the banner of biodegradable. That sodium, an element known to be toxic to many plants with a potential for soil structural collapse, is permitted to be used as a "filler" is counterproductive to environmental goals, yet advertising does not permit the consumer to choose products low in sodium.

7 CONCLUSION

Politically the reuse of greywater may encourage individuals and communities to lowering demand for drinking water while contributing to some environmental benefit. The constraints upon simple actions during periods of water restrictions are thwarted by a bureaucracy bent on covering the maximum risk to public health and imposing unreasonable guidelines. However, what has been missed is the significant risk to the environment of unregulated greywater discharges on small parcels of land with respect to salinity and sodicity issues. With an emphasis on water conservation and rebates for front loading washing machines, there has been no effort to educate the community about the consequences of salinity and sodicity on their own patch or cumulatively on their landscape.

While health departments are concerned about public health, the government sits and watches laundry detergent manufacturers market products that are unsustainable for greywater reuse. Many products are entirely suitable and present low environmental concerns, there are many products that are environmentally hazardous for land application unless amelioration is addressed. The laundry detergent you select is not even 'hit and miss' with regards to salinity or sodicity. There is simply no labelling that allows you to determine the potential impacts of the products when the washing machine water is discharge to land as greywater reuse.

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