HOUSEHOLD SOLUTIONS TO END-OF-LINE RE-USE PROBLEMS

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ABSTRACT

The re-use of water is important for both the on-site disposal of septic tank effluent and the irrigation projects from sewage treatment works. In each case, the wastewater from domestic residences into each system is a cocktail of chemicals over which there is no apparent control or regulation. The effects of the chemicals on the treatment process and the end-of-line re-use of the water appear irrelevant in the choice, purchasing, use and disposal of common household cleaning and personal hygiene products.

This project draws together data which show the chemical inputs to the domestic wastewater stream and the mainly inorganic compounds used for cleaning, such as laundry detergents. These products are labelled in a way that the community's ability to adequately improve the effluent quality is seriously impeded. As load based licences are introduced, it will be important for the community to reduce inorganic chemical loadings or face significant increases in licence charges. For on-site systems, the effective operation of the soil absorption field or the surface irrigation areas is correlated with the chemistry of the effluent and the impact of sodium salts, in particular, on soil hydraulic properties.

The data show that the ability to reduce the chemical load of the domestic wastewater stream is influenced by catchment geology and water treatment processes as well as the use of a wide range of chemicals within the house. While water conservation is espoused, high pressure reticulated water systems reduce the impact that water saving devices may have. Retro-fitting pressure limiting valves is recommended. However, a commensurate reduction in chemical loading must be practised.

The outcome is that while the criteria for load based licences penalise inland systems because of catchment geology, a genuine reduction in household chemical use is possible provided effective labelling is enacted. Households can be effective in reducing salt loads and have a positive impact on potential re-use options. Thus end-of-line solutions are solved at the household where product shifting can be both cost effective for re-use projects and on-site wastewater management.

KEYWORDS

Detergents, load based licence, phosphorus, salinity, sodicity, wastewater,

INTRODUCTION

Two types of re-use systems of domestic effluent are common across Australia, the largest operations being those using effluent from sewerage schemes. The second is from the individual and small community on-site wastewater treatment systems, many of which utilise irrigation of a chlorinated effluent around the dwelling, or non-chlorinated effluent by sub-surface absorption. Effluent management from Australian sewerage schemes has been addressed by the National Water Quality Management Strategy (ARMCANZ and ANZECC, 1997), using a central philosophy of ecologically sustainable development (ESD). The principles espoused include a five tiered hierarchy of waste minimisation, recycling, reuse, reduction of potential degrading impacts and discharge to the environment. The first principle may be regarded as politically difficult, while recycling and re-use are well documented. Many local authorities are expanding trial areas to use a larger volume of sewage treatment works (STW) effluent. The last two principles are regulated under current state licence-to-pollute legislation.

On the northern tablelands of New South Wales (NSW), the Armidale City Council has taken the results of soil tests from a 30 year-old re-use scheme to plan an expansion of effluent irrigation, lifting the proportion of re-use water from its current 6% of annual discharge (Patterson, 1997a). In this way, the Council aims to address three of the five principles in a least cost manner.

The economic benefit of re-use schemes, either from commercial woodlots or pasture grazing opportunities, is the aim of many such schemes. However, a second driving force in NSW is the Load Based Licensing Scheme (LBL) to be imposed by the Environment Protection Authority (EPA). Sections of the proposed regulations (EPA, 1998) are specifically targeting STW effluent discharges (Appendix A70). Two levels of fees will apply: a fixed administration fee based upon the annual licenced discharge volume; and a second variable and weighted fee based upon assessable pollutants. Discounts will be available for effluent application to land under strict monitoring conditions, thus, an increase in land application is expected as local authorities attempt to minimise LBL fees.

Many of the STWs in NSW are within their planned operational life and unable to meet the proposed strict LBL criteria for effluent disposal without serious financial consequences. It is, therefore, imperative that the management of wastewater be targeted at the least expensive options for effluent management. The current wastewater stream is a cocktail of chemicals over which the local authorities only control the trade waste licensees and mostly neglect the cumulative impact of thousands of homes. Both the domestic and commercial sectors need to be encouraged to reduce the organic and inorganic load and, in a positive way, contribute to the minimisation of solid and chemical loads.

The same five principles should apply to on-site treatment systems where opportunity exists for recycling and re-use. However, the loss of permeability in the soil disposal area is linked with the chemistry of the domestic wastewater produced and this impact is poorly understood by either regulators (EPA and local government) or by the individual on-site operator (residents).Whether on-site systems dispose of effluent by surface irrigation or sub-surface seepage, the problems of effluent chemistry impinge negatively upon the disposal field. Changes to the size of septic tanks and extension of drainfield are irrelevant for sustainability or public health unless the soil system is aerobic and hydraulically efficient.

This paper examines the opportunities available to improve the chemical and physical properties of the domestic wastewater prior to it reaching the STW, or on-site system, and thus benefit later re-use options. Solutions in the household may well prove more cost effective than technologically complex treatment systems and other end-of-line solutions. The debilitating effects of salts, in particular sodium, and heavy metal contamination should be addressed prior to irrigation. Waste minimisation is the operative principle when addressing manipulation of the domestic wastewater stream.

THE PROJECT

The data from several research projects in both on-site effluent disposal and STW irrigation projects have been collated, together with surveys of domestic households, data from trade waste monitoring programs and specific research into household detergents and other chemicals. The study has not been exhaustive, but is on-going, as the combinations of household chemicals and the irregular and haphazard use of these products thwarts simple sewer monitoring methods. The implications, however, lead to rational conclusions about wastewater quality management before entry to the wastewater collection system.

WASTEWATER PRODUCTION

Urban domestic water consumption

Two mechanisms control the use of water within the home. Firstly, dwellings connected to a reticulated supply are often separated psychologically from the processes which influence the collection, treatment and distribution of clean water to the household. At values around $0.50 per kilolitre in a subsidised reticulation system, water is expected to be available on demand in whatever quantities the individual household may desire to consume. Thus, consumption of water is driven by expectations and water conservation is less important than water quality. Figure 1 shows the consumption of water by the Armidale City (population 23,000) over the period May 96 to April 1997 (Patterson, 1997b).The comparison between clean water production and sewer receivals indicates the proportion of losses from the system such as through external domestic uses including lawn watering, motor vehicle washing and leakages from the system. Domestic water consumption, as measured by STW receivals averaged 190 Lpd for spring and autumn and 262 for each of winter and summer. The reason for the differences has not been pursued.

Rural domestic water consumption

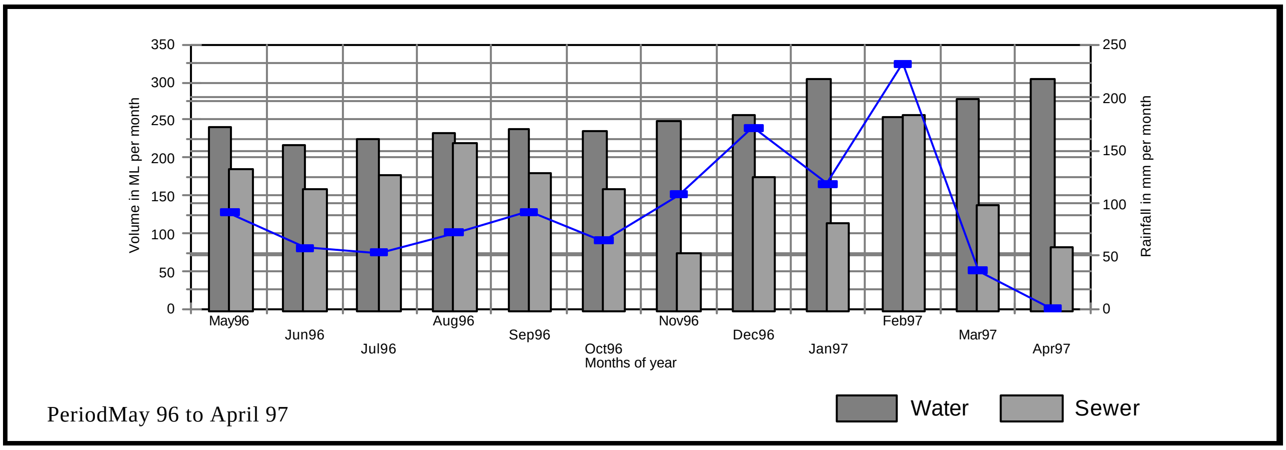
The rural residential areas are intricately linked to the water collection system and demand is progressively dampened as supply decreases. The majority of rural dwellings have poorly correlated catchment:storage ratios such that water shortages are common, even though water conservation is practised widely. Water consumption from rain water supplies has been measured at between 126 and 165 Lpd (Patterson, 1982). However, as on-site septic tank treatment of domestic wastewater is typical in rural areas, conservation of water is a greater priority where systems have been traditionally under-designed. In NSW, the average length of an approved drainfield is 20 m (Patterson, 1994), well short of the length required under the current AS1547-1994 in relation to effective hydraulic loading.

Water pressure influences

The most significant difference between the supply of water to each household type is water pressure. For the rural residential dwelling, either gravity supplies of less than 6.0 m head (59 kPa) or pressure pumps operating at 130 kPa provide water from the rainwater storage tanks. In Armidale, water pressure of 400-600 kPa is common for residences connected to the reticulated water supply.

Water pressure has a direct influence upon water use. Many water conservation devices, such as shower roses, fail to satisfy the users because of either insufficient water to wash oneself or a stinging stream of water from increased velocity. Thus, water conservation devices have received poor acceptance because of failure to adjust water pressure commensurate with the device. The plumbing codes were developed many years ago to provide unrestricted water to each fixture. While such practices may provide maximum user satisfaction,

Figure 1. Clean water and wastewater volumes for the City of Armidale for 12 months



the volume of water entering the sewer is maximised. The retro-fitting of pressure reducing valves to the house may compulsorily reduce water consumption.

In an exercise to minimise water use, a domestic water system serving seven persons was modified by replacing a pressure pump (130 kPa) with a gravity system (78 kPa) and fitting water conservation shower roses. An immediate saving of 38% in water consumption was measured. After dual flush toilets were fitted, an additional 18% water saving reduced the overall consumption from 160 Lpd to 84 Lpd. The effects of reduced wastewater production had a positive impact upon the septic drainfield operation.

Stormwater

Stormwater entry into sewers from accidental breaks and intentional connections causes considerable dilution to the wastewater stream and may overload a borderline system. While these additions decrease treatment efficiency, the matter of illegal connections can be reduced by adequate inspections.

COMMERCIAL REQUIREMENTS

Trade Waste Licensing

The objectives of trade waste control programs are to minimise the cost to the community of processing trade waste, to ensure environmental protection and encourage waste minimisation (ARMCANZ and ANZECC, 1994). As an example, Armidale City Council requires various categories of commercial establishments to enter into legal agreement (ACC, 1996), limiting the disposal of specified substances by concentration. Typical acceptance limits are presented in Table 1.

TABLE 1. General Acceptance Limits for Trade Waste into Armidale's Sewers.

Parameter	Limit	Parameter	Limit
BOD_5	300 mg L^{-1}	Total oil and grease	< 100 mg L^{-1}
Suspended solids (TSS)	300 mg L^{-1}	Ammonia (as N)	50 mg L^{-1}
Total dissolved solids (TDS)	< 4000 mg L^{-1}	Total Kjeldahl nitrogen (TKN)	100 mg L^{-1}
Detergents	biodegradable	Phosphorus	20 mg L^{-1}
Temperature	38°C	Sulphate	100 mg L^{-1}
pH	7.0 to 9.0	heavy metals	mass limit

While ever the limits remain in concentration values, there will be an opportunity for the commercial operators to dilute the wastewater stream because the value of the additional water may, in the short term, be lower than the value for increased on-site treatment. In line with the load based licence fees for sewerage systems, the trade waste licences should be similarly targeted at loadings. For example, the significant penalties for phosphate emissions suggest that individual connections to sewer cannot be permitted a 20 mg L^{-1} phosphorus limit when the licensed operation is restricted to less than 0.3 mg L^{-1} and a pollutant weighting factor of 680 compared to zinc (7), copper (120) and lead (770) (EPA, 1998). It would seem that there is a distinct financial advantage of discharging effluent to open coastal waters.

Congealed fat and cooking oil from commercial premises is viewed as a problem for sewer maintenance. Chapman (1998) associated 15% of sewer overflows in Armidale to caking of greases on the inside of sewers. However, the greatest area for such blockages was in the residential areas and not the commercial district. This suggests that the trade waste controls are working, but that similar restrictions may be necessary for residential areas. One of the problems of modern cooking processes is that the vegetable oils are not removed by grease traps as are the animal lards.

The legal requirements for commercial enterprises is not matched by similar restrictions on domestic premises, yet the cumulative impact of many thousands of homes needs to be addressed.

DOMESTIC CHEMICAL DATA

Product labelling

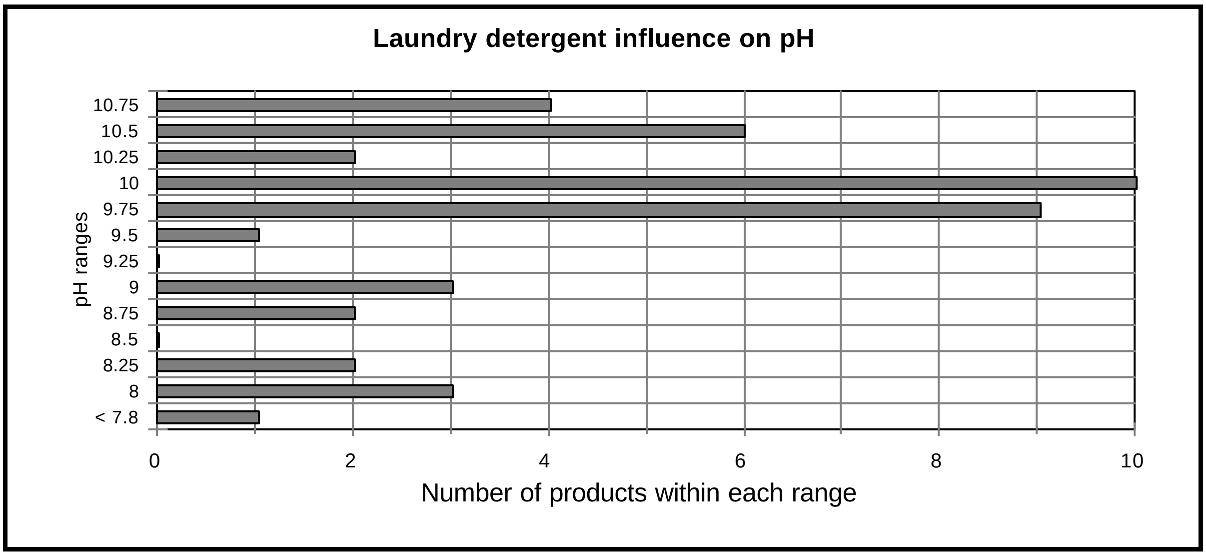
While householders should be aware of the direct consequences of their in-house operations on the final effluent, the underlying implication is that product labelling is not designed to inform, rather to entice to purchase. For example, laundry powder detergents are sold by mass, yet are clearly measured by volume. With few exceptions, the consumer has no ability to calculate the cost per wash from product labelling and package price. When a 40 mL scoop was used to measure a range of laundry powders, the results were Ajax Plus (48 scoops per kilogram), Castle (27) Fab 3 (51), and Savings (25). The values of a single wash were \$0.64, \$0.37, \$0.78 and \$0.59 respectively. The difficulty of choice is obvious.

The impact of laundry detergents on TDS, sodium and pH in normal washing use within the house is unclear from the labelling. The advice “People with sensitive skin should avoid prolonged contact with the washing solution” is difficult for the non-scientific person to convert into the understanding that the product, at its suggested concentration, will produce a pH above 10 and that caution is required. Figure 2 indicates the range of pH values for powder and liquid laundry detergents. Under trade waste agreements, most laundry water would constitute an illegal discharge to sewer.

The laundry products packaging provide no information on which to base sound environmental choice. The labelling of “NP” is presumed to mean no phosphorus, yet under labelling codes it only means no added phosphorus other than what may be in the separate compounds. The label “P complies with agreed phosphorus standard” means that the product has less than 7.8 g phosphorus per wash, which equates to about 39 mg L^{-1} for a total wash. This level is twice the allowable limit for commercial premises, as discussed above, and not an acceptable discharge to sewer. The laundry issue of sodium is avoided in product labelling, yet this element is detrimental to land application of effluent.

Other domestic products are labelled in a similar manner, with little or no information on which to make an informed choice about its impact upon the environment

Figure 2. Impact of powder and liquid laundry detergent on Armidale’s town water (pH 7.85).



Effects of Domestic Use on Water Quality

In both wastewater systems, on-site and sewerage schemes, the impact of domestic use is similar. That the low water consumption has been shown above for the typical rain-water supplied household compared to the reticulated system, the chemicals added to each system have been examined. The typical septic tank effluent (STE) of the individual household is compared with the average across several urban STW effluents from northern NSW, as shown in Table 2. The STE is the outflowing liquid from the septic tank, not the liquid within the tank undergoing primary treatment.

The solids and organic fractions, usually resulting from diet, faeces, urine and other organic wastes, are common to both systems and are unlikely to be changed by altered consumer awareness. The chemical changes, as shown in Table 2, can be significantly influenced by consumer education and reduction will have positive impact upon future re-use options. Each of the above parameters is important in land based re-use schemes and essential for management of soil hydraulic conductivity and plant nutrition.

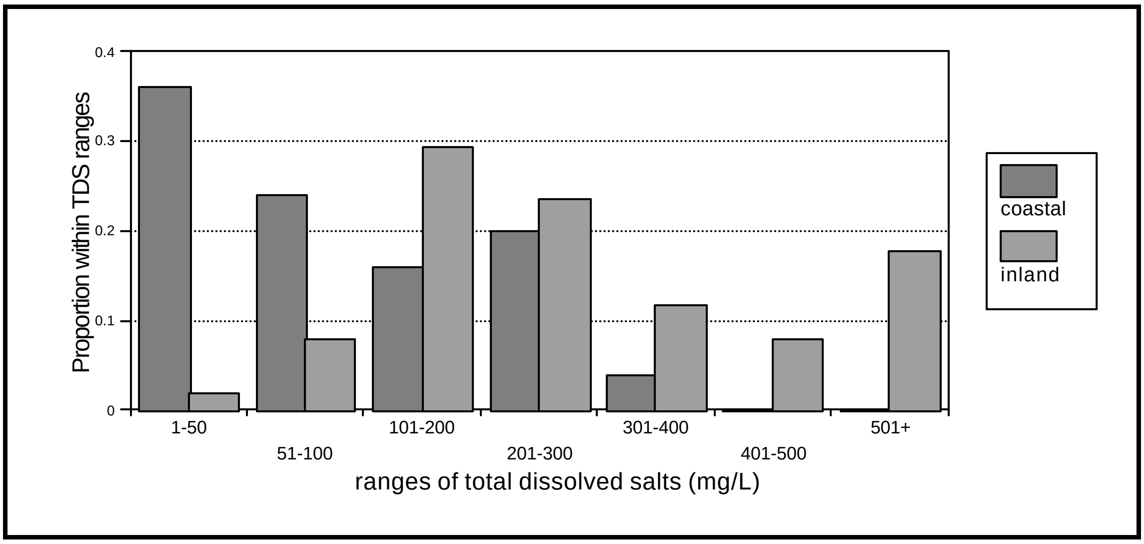
Clean Water Inputs

The clean water inputs to domestic uses are highly variable in their initial salt loadings, as measured by EC and equated to TDS, and the type of salts common to geology and land use in the catchment. Figure 3 indicates the variability of EC for reticulated treated urban water supplies across the north coast and northern NSW. Additional salts are used for the correction of pH, flocculation and softening.

TABLE 2. Increases in Chemicals in Single Households and Urban Wastewater

Parameter	**STE**	**STW effluent**	**Units of Measure**
pH	7.1	7.6	$\log_{10} H^+$
Electrical Conductivity (EC)	1.40	0.70	dS m^{-1}
Total dissolved solids (TDS)	0.84	0.42	mg L^{-1}
Phosphorus	14.4	6.7	mg L^{-1}
Sodium	96	84	mg L^{-1}
Sodium adsorption ratio (SAR)	3.6	3.9	dimensionless

Figure 3. Frequency ranges for TDS in clean water supplies for coastal and inland areas.



The load based licence condition for maximum discounts for land application of STW effluents is based upon the requirement that the effluent has an EC of less than 280 mg L^{-1}, which equates to 168 mg L^{-1} TDS (S.

Smith EPA, *pers.comm.*). It can be seen from Figure 3 above, that over half the clean water supplies from inland NSW would not meet that criterion. Add to this the contribution of salts from domestic and commercial uses within the sewerage network and none of 10 STW effluent analysed meet the zero pollutant management factor (maximum discount), while four failed the 0.25 factor. Each of the latter was an inland plant and had elevated clean water EC because of catchment geology.

Salt Load from Wastewater

The salt load in wastewater is a significant limiting factor in determining re-use options. A typical irrigation scheme designed for Armidale planned to use 6.2 ML effluent per hectare per year. The contribution of the chemical loadings is given in Table 3 below (Patterson, 1997a).

The salt loading is significant and needs to be addressed, particularly with respect to sodium salts which impinge upon the hydraulic conductivity of the soil, reducing the infiltration rate over time and causing a sodicity problem with respect to osmotic regulation in plants. Sodium is not a monitored component.

The salt load is derived from the use of laundry powders in which "fillers" or "bulking" agents are used but do not contribute to the washing process. Concentrated powders are the active ingredients without the fillers and are more acceptable, although not universally low in salts. The filler is usually sodium sulphate which contributes not only sodium cations but also sulphate anions. Other salts in the wastewater stream are derived from faeces and urine, cooking and food preparation and the salts from either geological origins or water treatment processes.

Such is the ability to reduce the sodium load, that for a household using a typical laundry detergent powder (average sodium concentration), a reduction from 28 kg sodium chloride equivalent to 9 kg per annum is achievable without any additional cost or loss of amenity. For Armidale (23 000 persons), that equates with a reduction of 87 tonnes of salt, about 26% of the annual salt discharge.

Heavy Metal Contamination

The contribution of heavy metals from the domestic wastewater stream should not be underestimated. Copper dissolves from the plumbing system, higher concentrations being measured from rainwater and groundwaters of low EC. The first flush from the kitchen sink has been measured at concentrations greater than 10 mg L^{-1} and in an exceptional case, 17 mg L^{-1}. Zinc is derived from galvanised pipes, roofing iron and rainwater tanks, an ingredient in dandruff medication, deodorisers and talcum powder. While the levels from individual households may be minute, the cumulative impact from thousands of residences may be significant when the total load is calculated. However, heavy metals from industrial processes are significant and should be controlled under trade waste agreements.

Table 3. Nutrient Status from Irrigation of Effluent onto Pastures in Armidale

Nutrient	Concentration in effluent (mg L^{-1})	Mass available in 6.2 ML (kg)	Plant removal rate per hectare (kg)	Excess or deficiency (kg)
Nitrogen (TN)	0.82	5	237	-232
Phosphorus(TP)	6.7	42	32	10
Potassium (K)	16	100	166	-66
Total salts	393	2440	est 400	2040
Sodium (Na)	70	434	38	396

CONCLUSION

The two driving forces for reducing the chemical loadings in domestic wastewater will be the load based licence penalties and the opportunities for ecologically sustainable re-use projects, in that order. Unless the residential sector shows the same responsibility, as the commercial enterprises, for reduction and minimising chemical use, the problems of reducing loads at the STW will be expensive. The direct savings to the community, by chemical reduction, will be realised in reduced LBL fees and penalties.

Only through education will such a campaign be achievable, since it will not be possible for local authorities to monitor domestic sewer discharges. The regulation of labelling standards will make the decision by individuals easier to interpret and enact while reduced availability of particular products will encourage investments in research into "sewer safe" products. These latter two recommendation are probably "too hard" politically but are possible under the Waste Minimisation and Management Act.

For on-site disposal, the reduction in chemical loads will enhance the ability of the soil to absorb and treat the effluent without loss of design loading rates. While the operation of the septic tank will remain unaffected, the benefits for either surface irrigation or sub-surface percolation will better satisfy sustainable disposal on small on-site disposal fields.

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