Modifying Wastewater Inputs to On-site Systems

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MODIFYING WASTEWATER INPUTS TO ON-SITE SYSTEMS

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Abstract

The cocktail of chemicals in domestic wastewater presents a significant problem for on-site application to the soil and plant environment. Highly corrosive and toxic chemicals are available for indiscriminate use within the household, for subsequent disposal to the wastewater stream. Many of the chemicals are capable of inducing soil dispersion and loss of hydraulic conductivity while others are potential bactericides, destroying essential soil microbes and diminishing within-soil treatment expected of irrigation or disposal areas.

The key to the modification of the chemistry of the wastewater stream is to reduce water consumption and remove products at source, that is, prevent their entry to the wastewater stream. However, the alert consumer is unaware of the components in many household chemicals, and inadequate labelling ensures that such ignorance will continue. Labels with confusing messages are typical among many household products, particularly laundry and kitchen cleaning agents.

Additional treatment, new treatment technologies or improved monitoring will not address the significant problem associated with chemicals such as sodium and strong acids and strong alkali materials. Removal of the offending products from the supermarket shelves appears to be the most immediate solution together with "low sodium" initiatives for household cleaning products.

Keywords

detergents, household chemicals, washing machines, wastewater, water conservation

1 Introduction

In recent years, a plethora of protection of the environment, pollution control and environmental planning legislation has been enacted across many Australian States. Typical is the NSW legislation (NSW Government, 1998a) which requires the use of specific guidelines (DLG, 1998) for on-site wastewater management, and provides performance criteria for wastewater treatment devices and effluent disposal. The acceptance of an almost endless range of products, without commensurate regulations for "septic tank safe" products, results in wastewater having an extremely wide range of chemical components. Indeed, the use of the term "sewage" rather than "wastewater" in the NSW legislation and guidelines indicates the paranoia surrounding "human faeces and urine" as defined by the Local Government Act (NSW Govt. 1993), rather than the range of other potentially environmentally hazardous products disposed of through a domestic wastewater system. Sewerage schemes suffer the same "avoidance" of other chemicals, yet Load Based Licensing, under relevant legislation (NSW Govt 1998b), proposes to "catch" polluters after the consumption has occurred. Trade Waste Licences attempt to avoid potential wastewater treatment problems (ARMCANZ and ANZECC, 1994) through the rejection of chemically inappropriate discharges to sewer.

As a consequence, planning for disposal based upon average chemical conditions is fraught with danger; that of under-estimating the pollutant loads in 50% of cases. Disposal areas are likely to be under-designed in relation to nutrient uptake, treatment or adsorption with the potential for off-site effects from overland flow and deep percolation. For the other 50%, where average levels of chemical components in the wastewater are not reached, system over-design results in additional costs borne by those households that are conservative in chemical use within the household.

The hydraulic loads from domestic dwellings can vary significantly depending upon water pressure, use of conservation devices, occupants' water-use behaviour and security of supply. However, while water use is easily controlled, or managed, and can be manipulated according to adverse climatic conditions, the use of chemicals within the household often goes unchecked. Indeed, there is much evidence to suggest that to the majority of household occupants, "*out of sight, out of mind*" applies to the wastewater system.

The term "*disposal*" is used in the context of this paper to refer to the numerous methods of soil absorption, evapotranspiration, and irrigation including drainage and deep percolation by which wastewater or effluent (treated wastewater) is returned to the hydrologic cycle. Its meaning infers that there may be some beneficial re-use of the liquid and nutrient components.

This paper addresses the opportunities household occupants have for reducing the chemical loads on soil application areas, through the wise choice of water saving devices and vigilance in purchasing and using common household products for laundry, personal care and general cleaning.

2 Water Consumption

2.1 Subdivisional requirements

Rural residential subdivisions are often required to have reticulated water supplies, even though connection to a sewerage scheme is not mandatory. With a secure, endless source of water, excess use of water within the house is controlled only through charges for water rates. The water fee structure for many NSW Council areas does not seriously reduce the consumption of water within the household, but may reduce the use of water for gardening and other aesthetic purposes.

The NSW guidelines (DLG, 1998) suggest that, as a planning value, water consumption should be based at 150-300 litres per person per day (Lpd) for houses with reticulated water. The source of the Department's value is not stated in the guidelines. The Australian Standard AS 1547-1994 (Standards Australia, 1994) indicates that 300 litres per bedroom per day should be used as a planning value, although no distinction is made between rainwater or reticulated water supplies. Similarly, no source to the data is given. Research by Patterson (1998) shows that for homes connected to the Armidale sewer, average wastewater generation was 262 Lpd for winter and summer. In earlier research, Patterson (1985) showed that in 100% of houses surveyed, reticulated water use was 500 Lpd. There remains a paucity of current statistics on water consumption by houses relying upon reticulated water compared to those only on tank water.

2.2 Water pressure

While a range of flow control devices is available for retro-fitting to pressurised water supplies, either reticulated or domestic pump driven, the benefits in reducing water consumption have not been espoused in the same way that low-flow shower roses and dual flush toilets have been advocated. The benefits of reducing household water pressure can be shown from the data presented in Table 1. An experiment was developed to show the reduction in water consumption from the use of a "*Control-a-flow*" tap jumper valve compared to a standard tap jumper valve in a domestic 15 mm cock. The "*Control-a-flow*" valve functions as a flow reducing device, limiting the rate at which water passes through the orifice when the tap is opened. The time taken to fill a 45.5 litre bucket was recorded over replicated trials.

The importance of these data is that water flow is proportional to the pressure, irrespective of the tap washer, a 51% reduction from 480 kPa to 210 kPa being achieved by pressure reduction alone. However, with the fitting of the "*Control-a-flow*" valve, at least 30% reduction in flow rate is achieved for the same pressure. With the change from 480 kPa without the special valve to 210 kPa with "*Control-a-flow*", a 62% reduction in flow rate is achieved. While the valve will not affect those persons who just "turn the tap on a few more turns", it will reduce wastage that occurs from hand basins, showers and laundry-tub taps. There can be no effect on toilet flushing or washing machine usage, as these devices are based upon volume, not rate.

Table 1. Variation in water flow at varying water pressures.

	Tap open one-half turn			Tap open one-full turn		
	Standard valve	"Control-a-flow" valve	Change with reduction device	Standard valve	"Control-a-flow" valve	Change with reduction device
Static Pressure kPa (m)	Flow rate L min^{-1}	Flow rate L min^{-1}		Flow rate L min^{-1}	Flow rate L min^{-1}	
480 (49)	51	32.6	- 38%	74	50.2	- 32%
410 (42)	40.4	26.4	- 35%	59.7	39.9	- 33%
345 (35)	35.3	23.9	- 32%	52.2	35.4	- 32%
275 (28)	25.6	17.1	- 33%	35	22.6	- 35%
210 (21)	21.8	14.8	- 32%	30.2	19.3	- 36%

1 kPa = 0.102 m head "Control-a-flow" is a trade mark of J.Fenwicke, Walcha

2.3 Washing machines

The choice of washing machine may result in reduced water use. The data represented in Fig.1 and Table 2 were compiled and further analysed from the results of 92 machines (7 repeats) tested by *Choice* (Australian Consumers' Association, 1994; 1997a, 1997b; 1998). The water used for the average number of loads of washes per week (7.3 loads), as surveyed by Patterson (1994), was calculated. At an average of 5 kg per wash for a top loading washing machine, an average of 36 kg is washed weekly. In the later three tests conducted by the Australian Consumers' Association (ACA), wash loads were less than the manufacturers' stated levels. The weight of the load tested are reported below, together with the rating for the "dirt removal score (%)". Prices, as quoted, applied at time of ACA's publication.

The major differences between front loading and top loading machines are presented in Table 2.

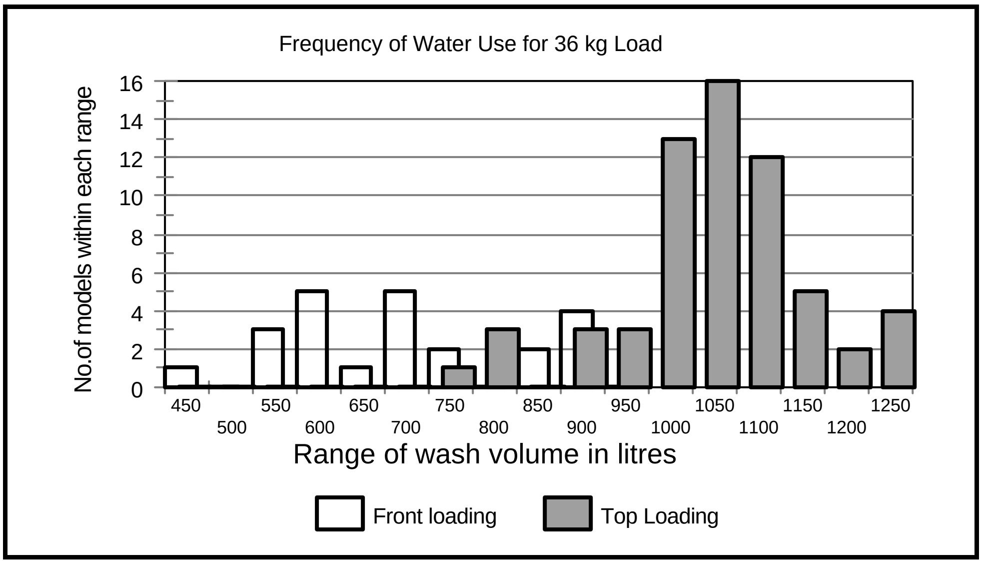

Figure 1 Frequency distribution of water use by washing machine type
(source: Patterson, 1998b)

Seventy six percent of households have top loaders (Patterson, 1994), 19% had twin tubs and 5% used front loading washing machines. Other considerations in the use of washing machines is the consumption of laundry detergent per wash.

Table 2 Comparison of washing machines by type

Parameter & range **Max - median - min**	**Front Loading** **(27 units)**	**Top Loading** **(65 units)**
price range ($)	820 - 1195 - 1999	569 - 870 - 1599
water consumption for 36 kg (L)	439 - 657 - 900	749 - 1001 - 1251
dirt removal score (%)	71 - 78 - 87	72 - 78 - 86
wash size (kg)	4 - 4 - 6	4 - 5 - 7.5
gentleness score (%)	70 - 77 - 82	46 - 60 - 72
wash cycle time (min)	46 - 71 - 125	35 - 50 - 60
spin efficiency (%)	32 - 65 - 78	43 - 57 - 75
overall efficiency (%)	68 - 74 - 81	60 - 66 - 73

(Source: Patterson 1998b)

2.4 Dishwashing machines

The ownership of automatic dishwashers is increasing in rural domestic residences in line with urban households. Patterson (1994) found that 24% of rural homes had a dishwasher, carrying out seven washes per week. Hand dishwashing occurred on an average of 16 times per week, and up to 30 times in households without dishwashers.

Australian Consumers' Association (ACA, 1997c) stated that improvements in recent years have reduced water use by dishwashers from 30-40 L to 16-27 L.

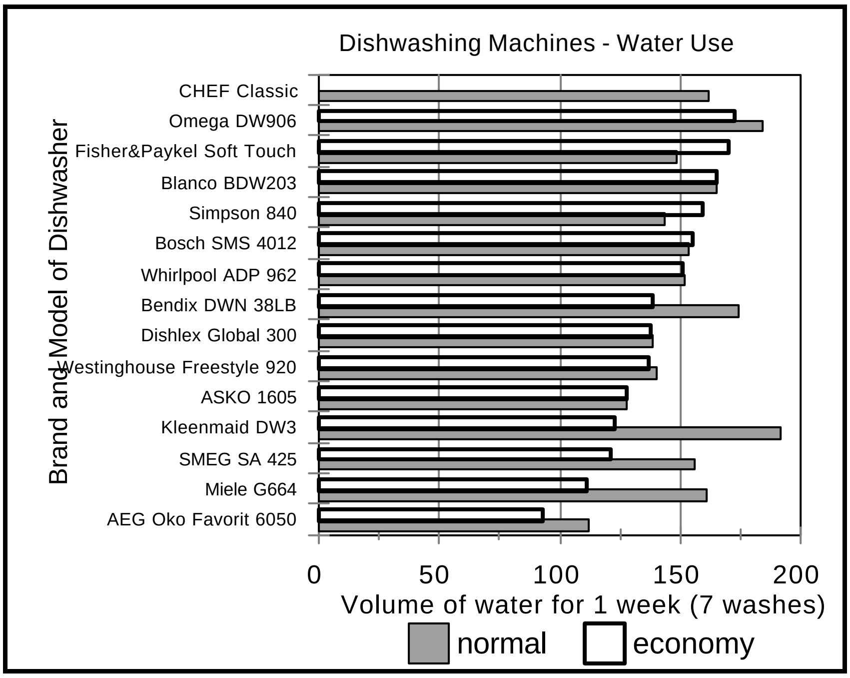

Figure 2 Comparison of dishwasher water use for seven operations per week (Source: Patterson, 1998b)

The data, presented in Figure 2 indicate the volumes of water used for "normal" and "economy" cycles for dishwashers tested by ACA (1997c), calculated for seven operations.

The Kleenmaid used 57% more water on the normal cycle compared to the economy cycle, while the difference was 45% for Miele and 29% for the SMEG. Six machines had no difference, while the Fisher & Paykel and the Simpson 840 used 13% and 10% more water, respectively, on the economy than normal cycles. Average prices of $1162 were in the range of $749 to $1799.

Average weekly water use was 153 L for normal cycle compared to 139 L for economy cycles. Prior to loading, all plates should be scraped to remove food scraps, oils and greases, not rinsed. The dishwasher should be operated at full capacity rather than partly filled. The environmental impact is not simply a result of reduced water use, but the combination of water, detergents and food wastes added to the wastewater.

2.5 Other water conservation devices

With the emphasis on water conservation in the metropolitan areas, driven by finite water catchment areas and storage facilities, numerous water conservation devices have arrived on the market. Sydney Water Corporation, through its many glossy publications is promoting water conservation. Economies of scale will reduce their price and become more widely accepted.

3 Household Cleaning Agents

3.1 Laundry products

The impact of household chemicals on the wastewater stream is no more evident than in the laundry. Powder detergents use a filler of sodium sulphate and numerous other sodium salts are carriers for surfactants and other constituents. Sodium, in high concentrations, is detrimental to both plants and soil particles, and reduces soil hydraulic conductivity

Part of the action of a detergent is to disperse stains and soil in clothes, hold those particles in suspension and prevent them resettling on the clothes. Other action by the detergents is to "make water wetter", that is, overcome surface effects which prevent water adhering to fabrics. Ameliorating the effects of calcium and magnesium salts, which impart hardness to water, may be a significant role for a laundry detergent in some areas.

Two major effects of using laundry detergents are related to the elevated level of sodium salts in the wastewater and the significant increase in alkalinity (pH >10). Both effects reduce the hydraulic conductivity of a soil and lead to destruction of soil structure and soil structural stability. Combined with the detrimental effects of sodium upon plants and nutrient availability, the loss of vegetation will reduce the evapotranspiration potential from the disposal area.

Figure 3 shows the significant increase in pH for a range of laundry powder and liquid detergents. The liquid detergents tend not to increase pH, while powders range through to above 10.5 from a clean water pH of 7.85 (Armidale) (Patterson, 1998).

It is unclear as to how a product which, when mixed with a full 150 L washing load, produced pH 10.8, can be labelled "For Sensitive Skins" and "Environmental Laundry Powder" (Concentrated *Aware*, a product of Bionomics Australia Pty Ltd). Such a high pH contravenes trade waste limits and could not be disposed of to sewer.

Figure 4 shows a range of laundry products tested with respect to sodium. Since sodium salts are always soluble, the removal at source is the most effective method of reducing the negative impact at the soil interface.

The data tabulated in Figure 4 have been measured for their impact upon the full washing machine water volume used, that includes the spin and rinse water. Even though the latest washing machines use less water in the full cycle, as shown in Table 2, the recommended dose of laundry product has not been reduced.

Of particular concern to on-site wastewater systems is the confusion over the use of the identifying symbols "**NP**" and "**P**". The former symbol invites the observer to assume that the product contains "No Phosphorus". However, the small print suggests that "this products contains no added phosphorus. Levels below 0.5% may be present" (Bushland Laundry Powder, 2 kg packet, a product of Campbell Consumer Products). It is unclear as to how 0.5%, or 5000 mg kg^{-1} can be proclaimed as consistent with "No Phosphorus" advertising.

Similarly, the symbol "**P**" is used where "The symbol complies with the agreed Australian industry standard on phosphorus, which imposes a maximum content of 7.8 grams per wash." (Colgate Palmolive Pty Ltd labelling of Ultra Cold Power). Such a content equates to 52 mg L^{-1} for a 150 L washing machine load, or 39 mg L^{-1} for a 200 L load. When Load Based Licence limits for sewage treatment works effluent discharges are set at 0.3 mg L^{-1} (NSW Government, 1998b), the labelling fails to indicate the potential effects upon the environment. At 39 mg P L^{-1}, such wastewater would fail to meet trade waste discharges to sewer (ARMCANZ & ANZECC, 1994).

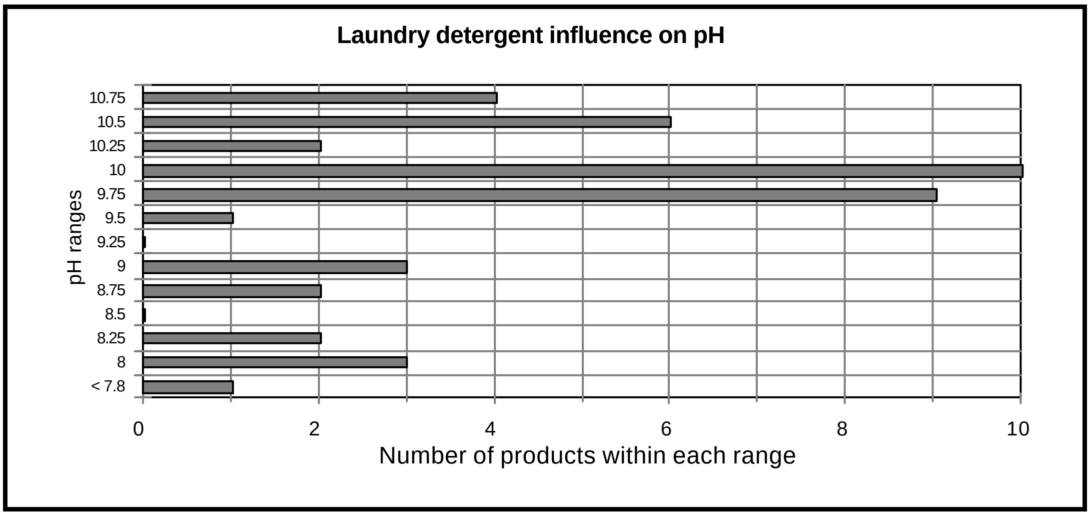

Figure 3 Impact of powder and liquid laundry detergent on Armidale's water

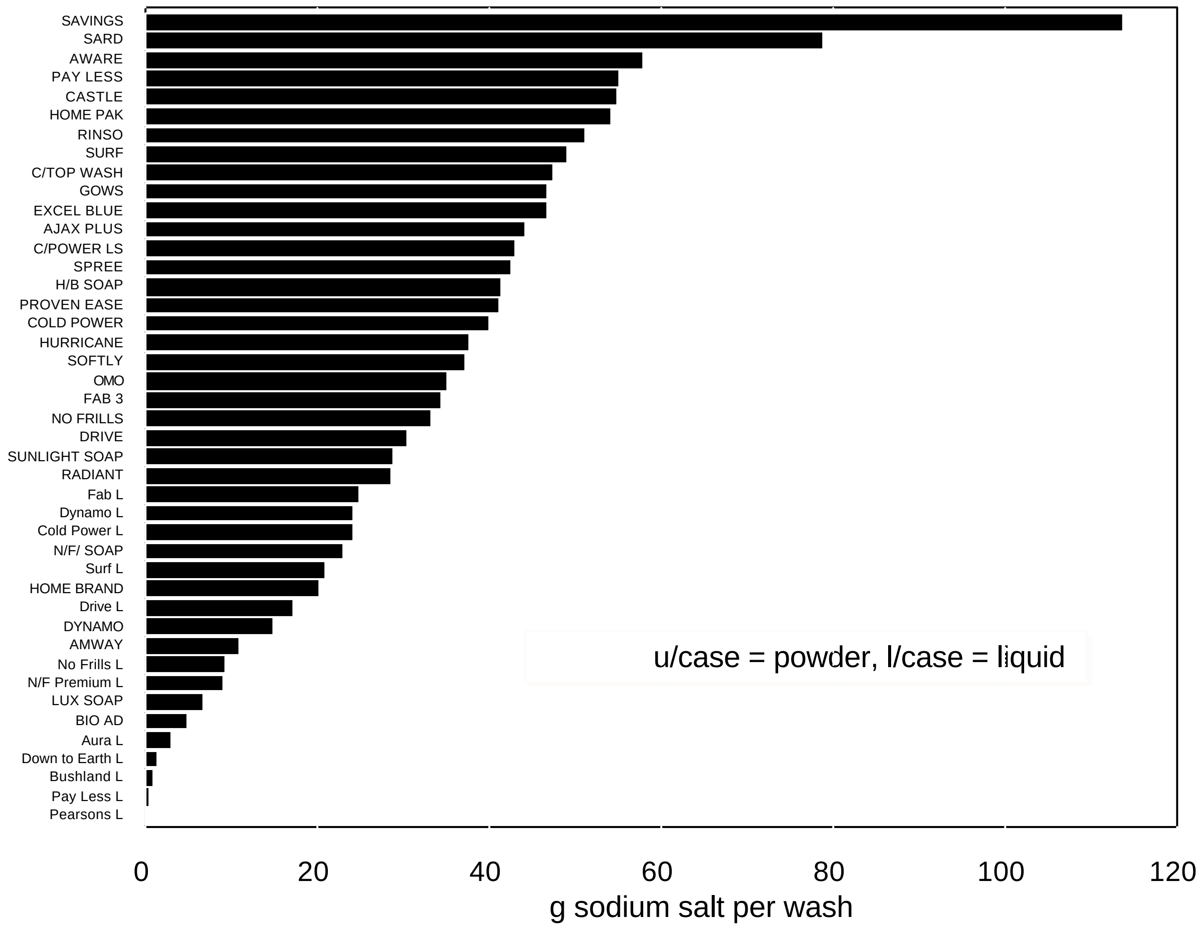

Figure 4. Sodium load for full wash using named laundry detergents (Patterson, 1994)

As the NSW Guidelines (DLG, 1998) require irrigation area sizing and longevity based upon a phosphorus balance over a 50 year disposal area life (page 116), the use of such labels must be entirely confusing, for not only the general public but for wastewater professionals alike.

Unlike phosphorus, sodium salts are readily soluble (hence their use) and move with draining soil water. Toxicity to plants and loss of soil structural stability are two significant effects of sodium in wastewater. Amelioration efforts are temporary and strategies for limiting the use of "fillers" in laundry products and changing from sodium to potassium based products must follow.

3.2 Other household chemicals

Other chemicals in the domestic wastewater stream can have a significant impact upon the soil to which the effluent is applied. Phosphorus is easily 'sorbed' onto soil particles and is most difficult to leach from the soil, but can move with eroded soil material. Phosphorus comes from not only laundry products but significant quantities from food. Cheddar cheese, for example, contains 5060 mg kg^{-1} (0.51%) and rump steak has 0.24% phosphorus (Patterson, 1998c).

Bactericides, such a bleach, will kill bacteria living in the septic tank and reduce the effectiveness of this primary treatment mechanism. Domestic bleaches may contain up to 5% sodium hypochlorite (active chlorine), 8 g L^{-1} sodium hydroxide (strong alkali), sodium carbonate (strong alkali), sodium perborate (powerful oxidising agent) or other corrosive chemicals. A single dose of one cup (250 mL) of bleach is sufficient to elevate the chlorine level in a 2000 L septic tank to 6 mg L^{-1}, a level three times that maximum recommended chlorine dose for treatment of effluent from an aerated wastewater treatment device.

Toilet cleaners (sodium hypochlorite and sodium hydroxide), drain cleaners (54% sodium hydroxide) and other highly corrosive chemicals are readily available for domestic use. The precautionary warnings on the labels of these products should suggest that their impact upon operations in the septic tank may be detrimental.

However, many of the labels appear to offer significant benefits to the consumer but the fine print states "*Caution - Keep out of reach of children. Read Safety instructions*" or "*Warning - Corrosive - avoid contact with skin and eyes*". But other products suggest relative safe products "*Active ingredients: 3% available oxygen*" without stating that the oxygen is connected with a powerful oxidising agent. Many labels do not report the concentration of the active ingredients but list either all or some of the constituents. It is not unusual to see labels such as "No hydrocarbons" or "contains no phosphates", rather than what is contained therein.

Greases and oils, derived from operations within the kitchen, are a cause for concern where greywater is disposed directly to soil. Modern cooking oils are liquid at ambient temperatures and cannot be removed by solidification. The use of high grade detergents in the kitchen carries the oils through a grease trap to the disposal field. Care must be given to the methods of disposal of oil where on-site wastewater treatment is practised. Less of a problem occurs where kitchen wastewater is directed to the septic tank, where longer retention and other solids assist separation.

The effective operation of an on-site system requires vigilance on the part of the occupants. Strong disinfectants and powerful acids and alkalis should be used with caution, apart for safety reasons, for the beneficial operation of the anaerobic bacteria in the septic tank and the aerobes in the drainfield. Indeed, labelling of household cleaning products should enjoy the same labelling required of commercial products - that of caution.

4 Conclusion

The potential cocktail of chemicals in domestic wastewater is derived not only from occupants' dietary habits, but significantly from the use of chemicals in personal and household cleaning tasks. While the restriction of water devices may be one method of reducing overall consumption of water, hence generation of wastewater, a commensurate decrease in the consumption of chemicals must follow, otherwise the concentration of those chemicals in the wastewater increases.

The householder's confusion over the range of potentially environmentally hazardous chemicals is almost without equal. Product labelling which is designed to "deceive", prevents the environmentally alert person from making informed decisions about suitability of the products for on-site wastewater treatment systems. With no codes of practice for "septic tank safe" products and ineffective labelling of product ingredients, the confusion is not only for the householders but for the professionals alike. That products are labelled as "safe for sensitive skins", when the alkalinity is sufficiently high to cause caustic burns, indicates the lack of understanding that product manufacturers have for wastewater treatment generally. That sodium salts are used as "useless" fillers in laundry products is "environmental vandalism" at a commercial level.

The removal of products from the supermarket shelves is, in many cases, the only option for removing the products from the wastewater stream. Treatment of the effluent, by either on-site or sophisticated off-site systems, is not possible for elements such as sodium.

A strategy for the reduction of sodium products from household cleaning products should be paramount for all households, not only those using on-site facilities. Sodium in sewage treatment works effluent has the same implication for land application and other re-use projects as it does in the effluent from septic tanks. Unlike phosphorus, which can be immobilised in the soil, sodium salts are always soluble and in elevated concentrations are toxic to plants and detrimental to soil structural stability. "Septic tank safe" research and labelling objectives require serious consideration for environmentally sustainable wastewater and effluent disposal.

On-site wastewater treatment and disposal (irrigation) requires improved labelling and consumer education. The effects of household chemicals needs to be more widely publicised and extensive research into chemical effects upon soil absorption areas must continue. Unfortunately the authorities appear more concerned with policy than action, developing guidelines based upon poorly researched assumptions. It is not expected that Government legislation will be effective, considering the labelling confusion over its well publicised Phosphate Reduction Campaign (NSW Public Works,1984).

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