

1. Introduction

1.1 Background

In years to come, archaeologists sifting through the remains of late twentieth century civilisation might well come to identify this period of history as one of waste - “the throw-away society”. In South Africa this is most clearly demonstrated by the large quantities of litter (alternatively called trash, debris, flotsam, jetsam, rubbish or solid waste) that is so often to be seen strewn about in public places.

The litter, consisting mainly of manufactured materials such as bottles, cans, plastic and paper wrappings, newspapers, shopping bags, and cigarette packets - but also including items such as used car parts, rubble from construction sites, and old mattresses - accumulates in the surrounds of shopping centres, car parks, fast food outlets, railway and bus stations, roads, schools, public parks and gardens, garbage bins, landfill sites and recycling depots. There it remains until it is either removed by the local authority, or it is transported by the wind and stormwater run-off into the drainage system.

Once in the drainage system, the litter is potentially able to travel via the stormwater conduits, streams, rivers, lakes and estuaries until it eventually reaches the open sea. Along the way, however, items are frequently entangled amongst the vegetation along the banks of the streams, rivers or lakes, or strewn along the beaches. Some of this debris is picked up - often at great expense. Most of it is probably buried in the river, lake or beach sediments (Hall, 1996).

The existence of such litter in the waterways and on the beaches has a number of impacts:

- Litter is aesthetically unattractive;
- There is a potential health hazard to humans associated with, for example, the putrefying contents of bottles and tins, or pathogenic organisms attached to discarded hypodermic needles;
- Aquatic fauna are at risk of becoming entangled in, or suffocating from, litter ingested in the course of their search for food;
- Pathogenic organisms or toxins, for example, heavy metals, may be taken into the food chain poisoning aquatic life and possibly later impacting on humans; and
- Significant costs are incurred by local authorities in conducting clean-up operations.

The purpose of this document is to discuss the most appropriate and cost-effective methods of removing the litter from the drainage system. It should be emphasised that the findings are still somewhat tentative in view of the limited operational experience of many of the structures described herein.

1.2 Definition of litter

Many different types of litter have been identified by researchers eg. Allison et al, 1996, Island Care New Zealand Trust, 1996, or Nel, 1996. A simplified classification system is proposed below:

- **Plastics** : eg. shopping bags, wrapping, containers, bottles, crates, straws, polystyrene blocks, straps, ropes, nets, music cassettes, syringes, eating utensils;
- **Paper** : eg. wrappers, newspapers, advertising flyers, ATM docketts, bus tickets, food and drink containers, cardboard;
- **Metals** : eg. foil, cans, bottle tops, number plates;
- **Glass** : eg. bottles, broken pieces;
- **Vegetation** : eg. branches, leaves, rotten fruit and vegetables;
- **Animals** : eg. dead dogs and cats, sundry skeletons;
- **Construction material** : eg. shutters, planks, timber props, broken bricks, lumps of concrete;
- **Miscellaneous** : eg. old clothing, shoes, rags, sponges, balls, pens and pencils, balloons, oil filters, cigarette butts, tyres.

Following the classification suggested by the Neville Jones - Willing & Partners Consulting Group, 1996, we could categorise this as “primary” pollution. Under this system, sediment and nutrient loads are categorised as “secondary” pollution, whilst faecal coliforms and pathogens are categorised as “tertiary” pollution.

The reduction of secondary pollution - primarily through the trapping and removal of silts washed off urban catchments - is only addressed in passing in this report. The removal of these silts from the natural environment is of great concern in some parts of the world as they may contain potentially dangerous concentrations of heavy metals, nutrients and pesticides of human origin. Much of the enormous capital investment made, for example, in Australia into so-called Gross Pollutant Traps - GPTs, has actually been with a view to trapping these sediments. These sediments are then dried and removed to hazardous waste land-fill.

In South Africa, very little attention has been paid to the environmental problems posed by the pollutants bound up in urban sediments. This is possibly because the problem of litter removal is far more obvious and pressing. Indeed, if maintenance and operation costs are to be at a sustainable level, designers in South Africa may be forced to chose litter removal structures that minimise the trapping of sediment. This difference in approach must be remembered when some of the Australian technology is considered later on in this report.

Although South Africa is a world leader in waste water treatment and most residential and industrial waste water is conveyed to an appropriately designed waste water treatment plant, very little attention is currently being paid to the removal of nutrients and pathogenic organisms outside of the sewage systems. An exception to this is the trap on the Robinson Canal in Johannesburg which does divert the heavily polluted low flows into the nearby Klipspruit outfall sewer. Given the existing financial restraints, this situation is unlikely to change in the foreseeable future.

Given the emphasis in South Africa on the removal of the larger pollution elements, the focus of this report will be on addressing the problem of primary pollution - litter. In the context of this report, **litter** is defined as **visible solid waste**.

1.3 The South African litter problem

Hall, 1996 suggests that the most common sources of litter are the following:

- the anti-social behaviour of individuals in dropping litter on footpaths, throwing it from vehicles, and dumping household wastes;
- the imposition of unwanted packaging on unwilling consumers;
- the failure of street sweeping services to rid pavements and public areas of litter;
- inadequate disposal facilities, including a breakdown in litter collection practices or the provision of inappropriate bins. Open bins and collection vehicles may provide an opportunity for litter to be blown into the public domain;
- a failure by the authorities to enforce effective penalties to act as a deterrent to offenders.

It is obvious that **litter is a problem associated with human habitation**.

It is also obvious that, to a point, the problem rapidly increases with population density and level of development. As a rule, traditional African villages do not have a litter problem. The inhabitants do not have access to many of the accoutrements of modern civilisation, and those they do have, they look after. Also, much of what they have is biodegradable.

Even the cities of so-called “less developed” countries are often cleaner than those of “more developed” countries. Litter is less evident in the streets of Harare and Bulawayo than those of Johannesburg and Durban. In general, this is because brown paper packets are used in place of polyethylene shopping bags, beverages are supplied in returnable glass bottles instead of disposable polyethylene sachets or bottles, and food is bought fresh instead of in tins. Unfortunately, as Zimbabwe becomes more developed, its streets are likely to become as polluted as those of South Africa.

Paradoxically, the streets of many developed countries are noticeably cleaner than those of Johannesburg and Durban. One reason for this could be a greater environmental ethic in those countries. Public pressure is rapidly brought to bear on the more obvious polluters and they are soon brought into line. An example from Australia graphically illustrates what a strong environmental lobby can do. Here in South Africa, a well-known international fast food company supplies its hamburgers in polystyrene containers. In Australia, public pressure forced the same company to replace the polystyrene with cardboard (Allison, 1996).

It seems therefore that the problem of litter in the stormwater drainage system is relatively speaking at its worst in countries which are developed enough to have the sophistication of modern technologies, such as the plastics industry, but not so developed that there is a strong environmental lobby in place to police the waste. South Africa falls into this category. As its population grows and becomes more urbanised, **the problem is likely to get worse before it gets better.**

1.4 The scope of the problem

According to the President's Council Report, 1991, South Africa at that stage was producing some 40 million tonnes of solid waste annually - mostly of domestic origin. A large portion of this amount was street litter, much of it packing material.

Nearly all solid waste pollution in our river systems is derived from the urban areas although they comprise only 5,6% (\pm 6 000 000 ha) of the land area of South Africa (President's Council Report, 1991). According to the CSIR, 1991, some 780 000 tonnes of waste was then entering the drainage system every year, of which about 195 000 tonnes reached the sea. The amount of waste being generated in South Africa is almost certainly increasing. The exact breakdown of the waste by category is not known - nor is its impact on the environment.

By way of comparison, at the time of above studies, the recycling of glass, paper and tins only accounted for 23 000 tonnes, although this amount is also on the increase.

South Africa is not the only country with this sort of problem. Local governments in Texas, for example, spend upwards of US\$14 million per annum to clean their beaches (Baur and Iudicello, 1990). Allison, 1997 recently estimated that 230 000 cubic metres or 1,8 billion items of litter (approximately 60 000 tonnes of wet material) annually enters the waterways of greater Melbourne.

Legislation alone is insufficient to control littering (Knoetze & McDonald, 1991). There are insufficient resources available to enforce the law, and the majority of offenders cannot be traced. The situation is particularly bad in the sub-economic communities where solid waste services are often not functioning properly and the inhabitants are more concerned with survival than environmental protection.

It is therefore clear that the **strategy** for the removal of litter from the stormwater system will have to be two-pronged, **aiming to reduce the quantity that finds its way into the system** in the first place, as well as **removing the balance as efficiently as possible**. This report focuses mainly on the latter.

It should be emphasised that the report only describes the current “state of the art”. It comprises a survey of some of the approaches that have been adopted around the world - particularly in Australia and South Africa - and describes extensive physical modelling undertaken at the Universities of Stellenbosch and Cape Town. From this research, it has become apparent that there are no cheap or easy solutions to the problem of litter removal. The most satisfactory way of reducing the amount of litter in the environment is to reduce it at source.

In addition to discussing the implications of research carried out locally and abroad, the report describes a number of litter removal structures - some successful, others less so. Most of the more successful structures have been patented and are available only from approved suppliers. Mention of a trade name does not indicate that the Water Research Commission or the authors necessarily support the product in question. They are described in this document in an attempt to show designers the sort of features to look out for in litter removal structures, and to indicate some of the better options currently available “off the shelf”. There may of course be other structures, not described in this document, that might remove litter from drainage systems more efficiently and effectively than those described herein.

1.5 The format of this report

This report has been structured in the following way:

Section 2 presents measurements and estimates made in South Africa and Australia into the quantity and types of litter being carried by stormwater systems in those two countries.

Section 3 focuses on some ways of preventing litter from getting into the drainage system in the first place, then goes on to describe the ideal litter trap and some of the difficulties experienced in the trapping of litter.

Section 4 describes some of the model studies carried out at the Universities of Stellenbosch and Cape Town into the optimum design of litter traps.

Section 5 outlines the search for a self-cleaning screen including additional work carried out at the Universities of Stellenbosch and Cape Town.

Section 6 looks at some of the problems associated with in-line screens, and describes some of the more successful designs.

Section 7 deals with the use of booms and baffles to deflect and trap litter with reference to a few examples.

Section 8 raises the possibility of using detention / retention ponds and wetlands as an opportunity to remove litter.

Section 9 looks at problems associated with vortex devices and describes one of the more promising designs.

Section 10 summarises the outcome of the research and describes the current best available technologies.

Section 11 proposes a method of selecting and locating litter trapping systems.

Section 12 discusses future research needs.

The following information is contained in the Appendices:

Appendix A lists the available information on some of the more promising “Off-the-shelf” devices for the removal of litter.

Appendix B shows how trap selection might be performed on an hypothetical catchment.

Appendix C provides some background information on the operation of hydraulically operated sluice gates.