The removal of urban litter from stormwater conduits and streams: Paper 2 - Model studies of potential trapping structures

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Abstract

A large quantity of urban litter is finding its way into the drainage systems to become an eyesore and a potential health hazard. Although much effort has been expended on the development of trapping devices, most of the traps currently installed are extremely ineffective at trapping and storing urban litter. There was thus a pressing need for a physical model study into the design of litter traps. Such a study was carried out in the hydraulic laboratories at the Universities of Cape Town and Stellenbosch. It clearly showed why most designs fail, and clearly identified the use of declined screens as an approach that holds considerable promise for the future. The findings broadly concur with the results of a similar model study that was recently carried out in Australia.

Introduction

Urban litter, defined as visible solid waste emanating from the urban environment (Armitage et al. 1998), and henceforth called simply "litter", is extremely difficult to trap and remove once it has entered the drainage system. Although much effort has been expended on the development of trapping devices, most of the traps currently installed are extremely ineffective at trapping and storing urban litter.

It is thus clear that there is a need for an inexpensive, reliable, effective trapping structure which ideally has no moving parts, is robust, is vandal-proof, does not require an external power source, is easy to clean (preferably self-cleaning) and does not increase flood levels in the vicinity of the structure. This clearly excludes the standard screens and de-gritting devices commonly found at wastewater treatment works. It also excludes the standard trash-racks comprising vertical or near vertical bars commonly found across river off-takes. With no surplus flow to scour them, these racks rapidly block from the bottom upwards. With this objective in mind, numerous candidate model structures were constructed and tested in the hydraulic laboratories at the Universities of Stellenbosch and Cape Town.

The tests conducted may be conveniently divided into two groups. Initially the investigation was mainly focused on screenless traps, or traps with a limited penetration into the water column (if the screen blocked, stormwater would still be able to pass the structure with limited upstream flooding). As it became apparent that screenless or limited screen traps were not efficient in the majority of applications, the focus of the investigation was switched to "self-cleaning" screens. The traps were generally conceived as structures capable of screening the relatively high flows to be expected at some point downstream of a fairly extensive urban catchment.

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Experimental method

For each model, water was supplied from a constant-head tank to a point upstream of the model structure, excessive vorticity was eliminated by passing the flow through a small reservoir and/or flow straighteners (usually in the form of bundled pipes), litter was added to the flow, the flow was passed through the structure, litter that was not trapped was removed by means of a downstream screen, and the water was re-circulated to the constant head tank. The flow was either measured with the aid of an orifice plate in the supply pipe from the constant head tank, or by the insertion of a weir (usually a V-notch) in the channel.

The width of the inflow/outflow channel was different for each model and varied from 280 mm to 900 mm. The nominal scale (which was required for the purpose of relating litter size, litter settling velocity, flow rate, length, depth and slope to prototype structures) was also different for each model, and varied from 1:25 for the smallest models to full scale for the largest.

Plastic chips were generally used to represent litter. Different litter fractions could be modelled by choosing plastic chips of different sizes and settling velocities (related to the shape and density of the chips). In the case of the full- scale model, polyethylene shopping bags were used as the representative litter fraction, as previous experience, both in the laboratory and in the field, had shown that these bags are simultaneously the largest single litter fraction (up to 60% of the litter load) and the hardest to trap (Armitage et al., 1998). The trap efficiency of each structure at each flow rate was expressed as the litter fraction trapped divided by the amount of litter released. These quantities were measured by counting the individual items, weighing the litter, or measuring its volume - whichever was most appropriate for the particular test. Particular care had to be taken where litter was weighed or its volume measured, as the results were easily distorted by water and/ or air bound up with the particles.

Screenless and partial penetration screen traps

One approach was to reduce the transporting capacity of the flow by lowering the average velocity to a point where the suspended