A multi screen device for the removal of urban litter

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ABSTRACT
Increasingly extended and alternative methods for urban stormwater management have been discussed in Australia, South Africa and elsewhere. There are no current trends of intensifying urban development which are useful for the stromwater problems in Malaysia. More recently, emphasis has been devoted to reducing both the concentration of flow and the discharging of the pollutants in stormwater from urban areas into watercourses or groundwater. Adding a number of frequently used gross pollutant traps has widely extended the applicability of an existing stormwater balance and pollution loading. Present paper discusses the best available technologies for the removal of gross pollutants and sediment.

Keywords: Best management practice; Gross pollutant traps; self screens; inline screens; multi screens.

1. Introduction

In about 70 % of developing countries trapping of gross pollutants is based on proprietary gross pollutant traps. Various traps were used considering size, shape, density and hardness of the pollutants. Inline screens, self cleaning screens, floating traps, baffles and sediment traps are the best available technologies for the removal of urban litter from various pollutant transport stormwater, drainages and ponds. Inline screens are most common form of litter removal device. They usually consists of metal bars racked at some angle 25° and 90° to invert the channel (in the direction of flow). They are usually mounted on the floor of the channel or on the top of a low weir wall. Self cleaning screens rely on the control of the flow velocity, the velocity gradient, and gravity to create the self cleaning action. Booms and baffles may be used to deflect and trap litter provided the flow velocities are low enough to allow desegregation of the liter in to bed-load and flotsam, and. Sediment traps designed to trap coarse sediments. Weirs were arranged in GPT structures to direct the water in to lower retention chamber. During the flows in excess of design capacity the diversion weirs are topped and flow is diverted from the retention chamber. Among all the available technologies self screens are having a good record in removing the urban litter from stormwater. (Armitage. N. 2007)

2. Technologies for removal of gross pollutants and sediment

Innovative and alternative concepts and technologies aiming at quality improvement of urban drainage and solving the stromwater problems. There are no current trends of intensifying urban development which are useful for the stromwater problems in Malaysia. Many technologies were developed in Australia and South Africa are being used to trap all size of pollutants. More recently, emphasis has been devoted to reducing both the concentration of flow and the discharging of the pollutants in stormwater from urban areas into watercourses or groundwater. These goals can be partly met through source-control, or on-site stormwater management, which involves detaining the runoff so as to trap contaminants at source and/or reduce flooding. The available developed technologies were categorized from the study of devises developed in Australia and South Africa. Based on the performance design conditions available technologies were categorized and depicted in Table1.

Table1 Available devices categorized from the source of MSMA 2000, Water Research Commission report No. TT 95/98 Australia and Melbourne Water sensitivity urban design.

Category	Devices	Country
Inline screens		
Gross pollutant traps	Canberra type,	Australia
Litter collection baskets	Baskets	
Boom division system	Hume guard	CSR Humes , Australia
Release nets	Nets	
Trash racks	Capel stoot culverts,	Cape town , South Africa
Return flow litter baskets	Ecosol RSF 4000 trap Nikolas sky jump trap	Australia Australia
Hydraulically operated trash racks	Robinson canal	Johensburg, South Africa
Self cleaning screens		
Circular screens	Continuous deflective separator (CDS)	Australia
Downwardly inclined screens	Baramy Trap	Australia
Multi screen device	REDAC GPT	Malaysia
Floating trap		
Flexible booms	Flexible boom intake	Slickbar prodcut corp. Aus
Floating debris	Sydney harbour litter booms	Australia
Sediment trap		
Sediment settling basins and ponds		
Circular settling tanks (Vortex devices)	Storm ceptor or Hume ceptor	Australia
Hydro dynamic separators	Storm king Down stream defender	Australia

3. In line screens

3.1 Gross Pollutant Traps

Typically a gross Pollutant trap (GPT) is a sediment trap with a trash rack (Figure 1). They generally consist of concrete lined wet basin upstream of a weir, with the trash rack located above the weir. This type is a combination of two types for the purpose of collecting pollutants that would otherwise pass one treatment or the other.

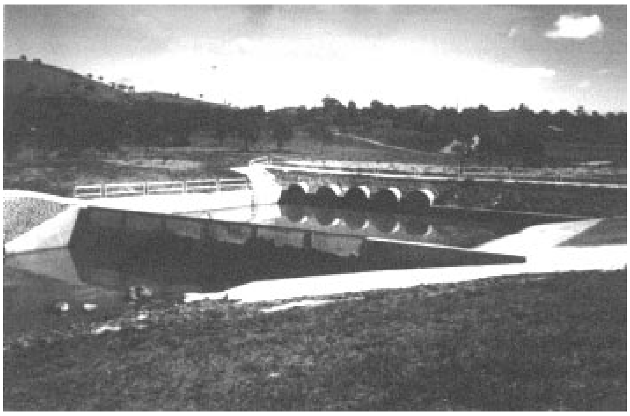

Figure 1 Tuggernong Lake, Canberra (WSUD)

3.1.1 Litter Collection Baskets

A litter collection basket is typically steel sheet basket with holes (Figure 2). The basket is situated below the invert of the inlet pipe. Water falls into the device and all particles greater than the hole size are retained. As litter is trapped the effective pore size is reduced and smaller particles are trapped. A drop in the channel bed from inlet to outlet is required to allow the waters to pass into and through the basket. Above the trap point (basket) an access port must be available to 'clean' the basket. The infrastructure cost are medium to high along with the maintenance costs, but is a simple and effective litter trap. This type of Litter Trap is useful in areas of high litter loads, can be retro fitted to existing drainage systems and has minimal visual impact. In comparison this trap has high installation costs and is limited by sufficient channel bed incline, it can get blocked and cause upstream flooding or re-suspension of the pollutants and can be a possible source of odors.

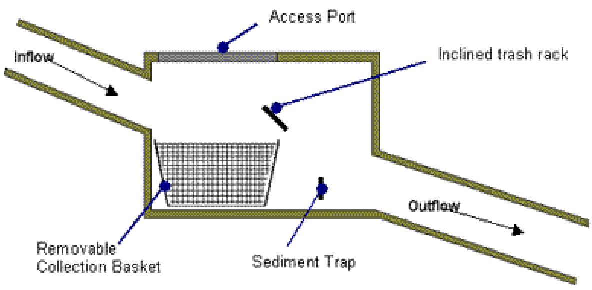

Figure 2 Litter collection basket (WSUD)

3.1.2 Boom Diversion Systems

This treatment type typically consists of a vertically hinged boom located in the path of the entering stormwater as shown in Figure 3. In low flow conditions the boom diverts all the flow into a screened collection chamber. During High flow conditions the boom only diverts floating items, with the majority of the flow by-passing the trap. The system can be retrofitted to existing drainage lines. Maintenance of cleaning is required typically monthly (US:BPEMG).

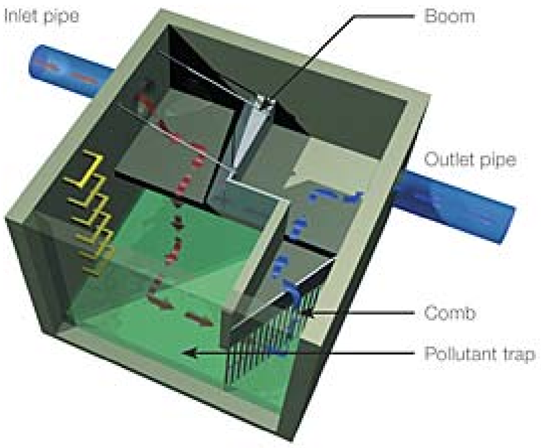

Figure 3 Hume Guard, (CSR Humes, Australia)

3.1.3 Release Nets

This treatment is simply netting attached over the outlet of a pipe (Figure 4). The net is typically shaped as a cylinder and length is dependent upon the catchment. If the design flow is exceeded or the netting is full (weight determined) the net can detach from the drain, with the net opening being chocked by a short tether. Its trapping ability is dependent upon the pore size of the netting used. It is visually unattractive and could be subject to vandalism but has simple, low installation costs, volume and pore size of netting can be changed at any time, easy to maintain and involving no manual handling of pollutants.

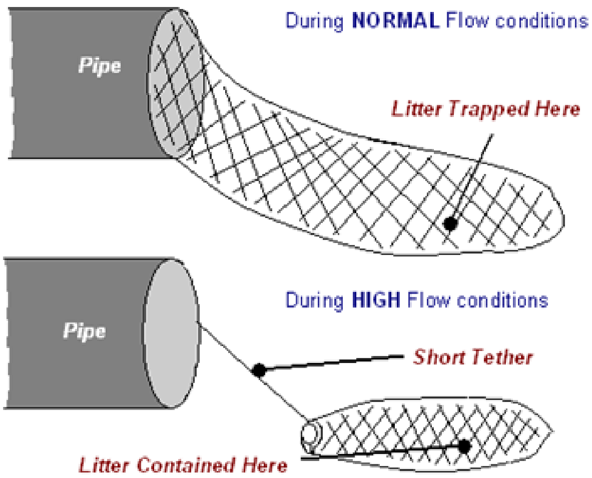

Figure 4 Nets (WSUD)

3.1.4 Trash Racks

Typically installed in drainage channels, the trash rack consists of vertical or horizontal steel bars spaced between 40-100mm apart (WSUD). As trash builds smaller particles can be trapped and is manually cleaned.

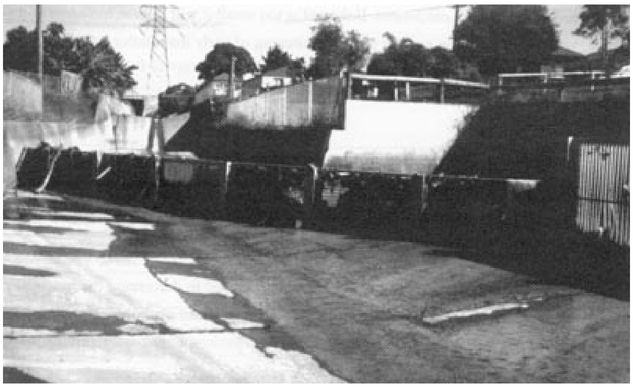

Figure 5 Cup and Saucer Creek, Sydney (WSUD)

3.1.5 Return Flow Litter Baskets

Water passes through the labyrinth, exiting near the inlet weir. Water leaving the labyrinth collection basket produces a hydraulically driven barrier that diverts incoming water in the collection basket. The force of the return flow from the water exiting the collection basket drives the barrier. The process operates in all flows except flood conditions, in which the flow bypasses the system.

Stormwater is filtered through a series of vertical screens prior to flowing under a fixed baffle, then over a weir. The sluice gate is operated during flood conditions to enable floodwaters to pass through the device. This type of treatment has minimal head loss, with high flow by-pass that avoids pollutant scouring. In contrast this trash rack involves intensive maintenance, requires a large area and is aesthetically obtrusive.

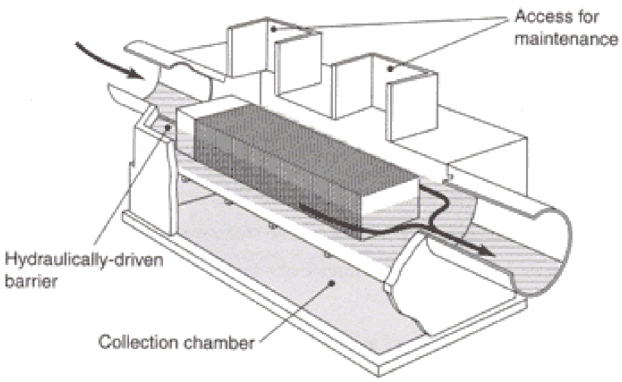

Figure 6 Hydraulically Operated Trash Racks (WSUD)

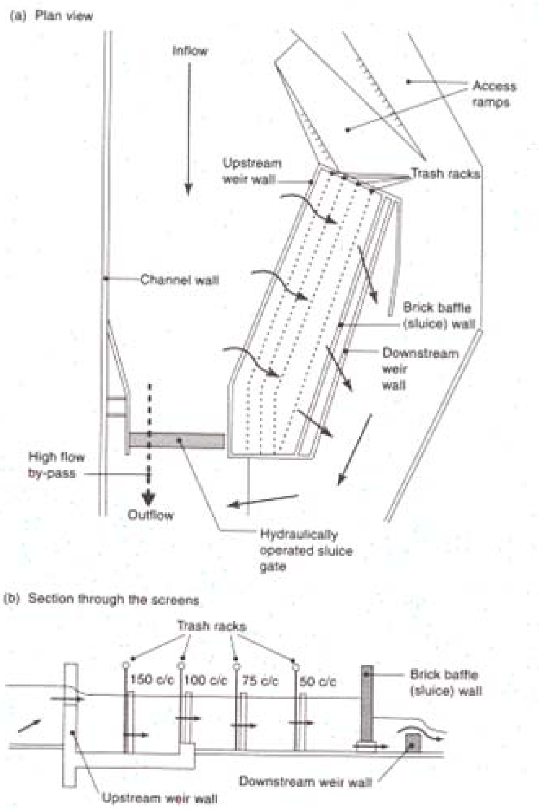

Figure 7 Hydraulically operated trash screen, Robinson canal (WRC report)

3.2 Self cleaning screen

3.2.1 Circular Screens

A circular screen separates pollutants and litter trapping them in a catchment sump. The circular motion serves to push the trapped litter down the trap into the sump, thus keeping the screen clean. These types of traps are considered to be efficient but have a high installation cost and moderate maintenance cost with a 2-3 monthly clean out. Monitoring of a CDS device (Figure 8) yielded a 90% of sediment in the sump was smaller than the screen mesh size by Walker et al (1999).

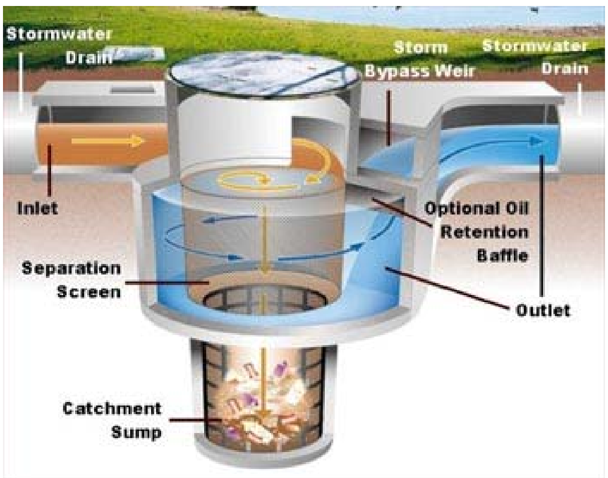

Figure 8 Continuous deflective separator (CDS Technologies)

3.2.2 Downwardly inclined screens

This treatment comprises a downwardly inclined trash rack with a pollutant holding shelf at its base. The water falls between the trash rack bars whilst the pollutants remain. The flow of water pushes the stranded pollutants down the rack onto the shelf for future collection. The Racks are typically between 20-45 degrees inclination from horizontal.

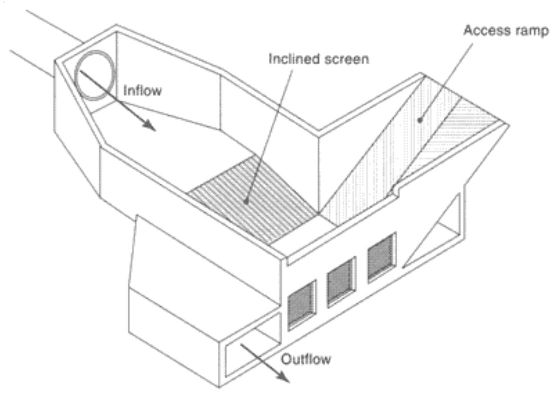

Figure 9 Baramy Trap (Baramy environmental products)

3.2.3 Multi Screens

REDAC Gross Pollutant Trap (GPTs) is a device for the removal of solids conveyed by runoff that are typically greater than 5 millimeters. The primary purpose of GPTs is to remove gross pollutants and coarse sediments washed into the stormwater system before the stormwater enters the receiving waters. A vertical trash screen is arranged at the downstream of the primary basin and inclined trashscreen at the secondary basin. Primary trap is designed up to storm water quality treatment recurrent interval (3 month ARI) where as secondary trap has designed to treat storm water with rainfall events exceeds 3 month ARI to serve the large quantity of storm water and also it functions as back up trap which is responsible to treat any storm flow whenever the primary trap is blocked.

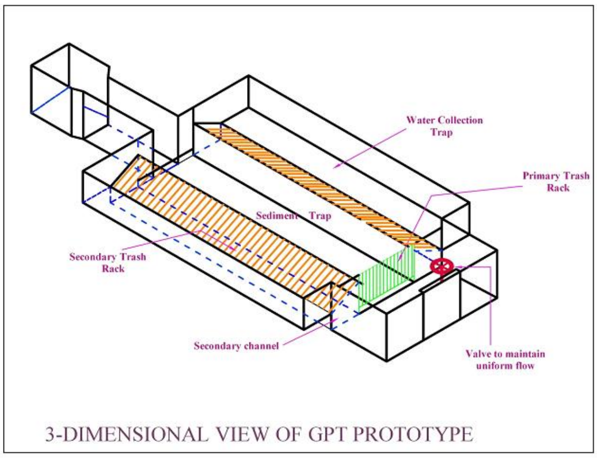

Figure 10 REDAC GPT, Malaysia

3.3 Floating traps

3.3.1 Flexible Booms

This comprises of a set of partly submerged floating booms located across a waterway. The boom collects floating debris as they travel downstream. This mobile trap can enhance the aesthetics of downstream waterways along with single location collection that is able to rise and fall with the flow. This type of trap is limited by its capture efficiency, fragility of booms, difficulty of maintenance and it can aesthetically obtrusive.

Figure 11 Flexible boom intake
(Courtesy of slickbar products corp.)

3.3.2 Floating debris

This type of trap has evolved from the flexible boom, floating trap. The changes involve more ease for maintenance and enhanced material retention capabilities. The booms of typically polyethylene have submerged skirts protruding into the water that deflect floating debris into the collection chamber. A one way gate at the opening of the collection prevents the escape of trapped debris, with a sliding gate at the downstream end providing access for cleaning.

Figure 12 Floating debris trap (Courtesy of stormwater systems, Inc.)

3.4 Sediment traps

3.4.1 Sediment settling basins and ponds

This type of structure is designed to trap coarse sediments. It typically takes two forms; a tank usually constructed of concrete or a pond typically constructed as an excavated hole. The enlargement of the channel causes sedimentation to occur due to the subsequent reduction in flow velocity. This type of trap is simple in both construction and design. Minimal fine sediment removal, large area requirements, the potential for pollutant breakdown in wet sump limit the sediment traps' applicability and it could be a source of sediment/pollutants during a high flow event due to scouring.

3.4.2 Circular settling tanks

A cylindrical tank, it is divided up into two chambers; the upper diversion chamber and the lower retention chamber. Waters are directed into the lower retention chamber by weirs. The waters exit the retention chamber through an outlet riser pipe, with the sediment collecting at the base of the retention chamber. During flows in excess of design capacity the diversion weirs are topped and flow is diverted from the retention chamber.
The trap is able to protect material from flood scouring, suitable for targeting specific problem areas with retrofitting ability and retains a high proportion of sediments. High initial costs and the likelihood of the inlet pipe to be blocked by gross pollutants limit this treatment type.

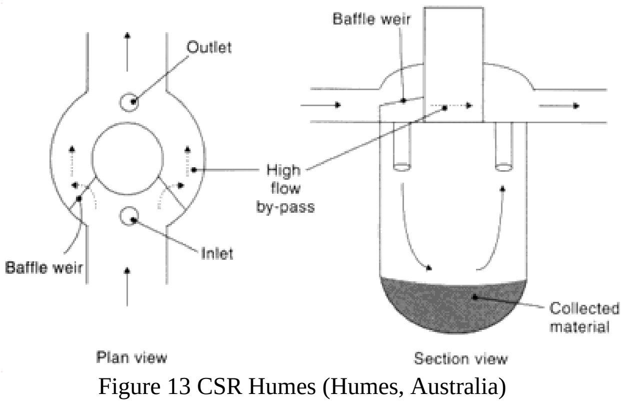

Figure 13 CSR Humes (Humes, Australia)

3.4.3 Hydrodynamic separators

This type of separator induces a vortex upon the entering stormwater. The system relies upon this vortex to separate the sediments from the waters. Two design categories are currently present. The first is a collection chamber at the base of the separator that is periodically cleaned. The second is the incorporation of a separate line that pipes the separated sediment and pollutants to sewer. The second category is essentially self-cleaning. This treatment type has a high removal rate with minimal maintenance for cleaning. It is limited due to cost, lack of performance data and as the flow velocity falls so does the removal rate.

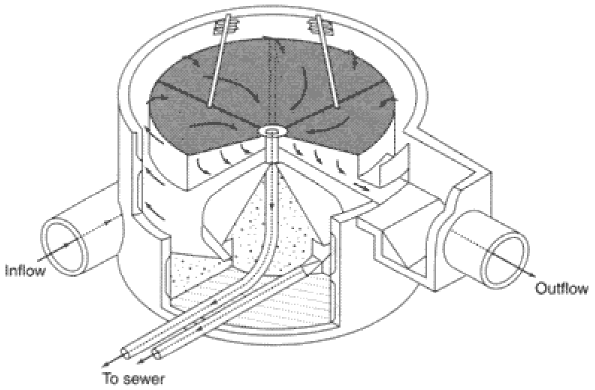

Figure 14 Storm King®, Hydro Australasia

4. Screens in removing the urban litter

An ideal trap can be defined as the structure is economical to construct and operate, it has no moving parts, does not require any external power source, having high removal efficiency and it should be self cleaning. It does not increase flood levels in the vicinity of the structure. All the structures are better in some situations than the other. Gross pollutant control plays an important role in stormwater management. From targeting visual contaminants such as litter, leaves or oils to pre-treatment of sediments prior to filtration devices, ponds or wetlands, Gross Pollutant Traps (GPT's) are a cost effective way to reduce your sites contaminant loadings and extend system maintenance frequencies.

Screens or trash racks works as the obstacle for the pollutants travel through stormwater. Trash screens were constructed by steel rods either in vertical or inclined direction to the direction of flow. Pollutants of different sizes were captured by the trash screens. Field observations have shown that screens are commonly blocked with organic matter due to infrequent cleaning. Blocked GPTs can cause upstream flooding resulting in storm water system becoming inoperable. During the high flood situations blockages of screens makes the traps absurd. High litter loads together with high rainfall intensities and unreliable maintenance programs frequently lead to blockages and the associated risk of flooding. Removal of litter from a stormwater is possible when the pollutants were obstructed by any screen. The modeling of neither a screen nor any obstacle led to the trapping of pollutants. Percentage of particles trapped by any structure is the trapping efficiency of that structure. Secondary screens / multi screens are useful when there are blockages of primary screens. REDAC GPT is developed with the secondary screens which is useful to trap the pollutants in case of primary screens blocked (Ab. Ghani et al., 2011).

5. Discussion

In general, based on the data supplied in Table 1 it appears that the self screen devices have a much higher economic efficiency than inline devices. (Armitage N, 1998) From the inline litter traps the main disadvantage with the GPTs, Trash racks and Hydraulically operated screens can be blocked during the high flood situations and is useful the process in all storm events except high flood conditions. And disadvantage with the litter baskets, boom diversion system and release nets suspended solids can’t be trapped. Self screens are better than inline trashracks (Armitage N, 1998) as because the self cleaning screens are having a capability of cleaning the screens causes the non blocking of screens. The disadvantage of the self screens it does not remove the dissolved and suspended particles present in the water column (Betty Rushton 2006). And downwardly inclined screens allow the sediment can’t to deposit. REDAC GPT offers the advantage of being a potential catchment management tool in removing the urban litter and sediment. It might also very useful in case of high floods and during the blockages of primary screens.

Fences, nets, weirs, booms or baffles may be the most cost effective structures of all, provided a suitable slow-flowing stream (which includes flows through detention / retention ponds and wetlands) is available. A major problem with these devices is cleaning and maintenance. Ideally it should be possible for the channel to be periodically drained for cleaning and maintenance purposes. Booms and baffles are useful to trap floatable materials not to trap the dissolved pollutants, and sediment traps are useful to trap the sediment only.

And it is found that REDAC GPT is having well Performance in removing the gross pollutant traps in case of primary screens blocked. A series of experiments were conducted and resulted that during the high flood conditions water overspills in to secondary tarp which leads pollutants were trapped by secondary screens. (Ab. Ghani et.al. 2011).

6. Conclusion

Adding a number of frequently used gross pollutant traps has widely extended the applicability of an existing stormwater balance and pollution loading. From the current research the study showing that out of all the available technologies self screens are more efficient in removing the urban litter and sediment without blocking the screens. And from the results of prototype test (Ab. Ghani et al., 2011) REDAC GPT is one of the best available technologies in case of multi screens for the purpose of removing the urban litter in high flood situations and blockages of primary screens.

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