Catch basin inserts to reduce pollution from stormwater

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Abstract Stormwater contamination represents the largest source of contaminants to many receiving waters in the United States, such as Santa Monica Bay in Los Angeles, California. Point sources to these same waters generally receive secondary or better treatment before they are released, and they are usually discharged through outfalls that diffuse the wastewater plume to prevent it from contacting the shoreline. Stormwaters receive no treatment and reach the receiving waters through a variety of ways, but most enter through catch basins or inserts to storm drains that terminate at the beach or in shallow coastal areas. Under these conditions, the stormwater discharge may have greater impact on the quality and utility of the receiving water than the treated wastewater discharges. One method of reducing pollution is to equip catch basins with an insert that can capture pollutants. A number of commercially available devices exist but few have been evaluated by independent parties in full-scale applications. A series of tests using bench and full-scale devices under both laboratory and field conditions were conducted to evaluate their ability to remove trash and debris, suspended solids and oil and grease in stormwaters. The results presented in the paper should provide a basis for future insert development and application.

Keywords Best management practice; catch basins; litter; stormwater; urban runoff

Introduction

Most industries and municipalities in the United States have full secondary wastewater treatment, and some have nutrient removal and filtration. As a consequence of these reductions in water pollution, stormwater now represents the greatest threat to aquatic habitants in the United States. Stormwater quality has been largely ignored in many areas, although there is usually concern for flood control and flood damage prevention. As a result, we have stormwater management systems that prevent floods at the expense of environmental protection.

Los Angeles is a good example of an area that has emphasized flood control at the expense of environmental protection. In this highly urbanized area there is little opportunity to reduce stormwater pollution through traditional means. The average imperviousness is more than 60% in many cases. Land values are such that it is prohibitively expensive to retro-fit storage basins or infiltration zones. This paper addresses a potential best management practice for such urbanized areas. The stormwater system has been constructed with catch basins, which may be several cubic meters in volume. These catch basins can be retrofit with devices, called “inserts” to capture pollutants. A number of commercially available devices exist, but few have been evaluated by independent parties in full-scale applications. The authors conducted a series of tests using bench and full-scale devices to remove trash and debris, suspended solids (TSS) and oil and grease (O&G). Field tests were also performed with boards, screens and baskets to observe their ability to remove or prevent debris from entering storm drains. The results are sufficiently promising to suggest additional testing with a variety of devices.

Background

Santa Monica Bay is the receiving water for a major portion of the City of Los Angeles

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metropolitan area. The watershed is 1072 km^2, and is largely urbanized, serving a proportion of the three million people in Los Angeles and more than 11 million people in the metropolitan area. Only two wastewater treatment plants discharge directly into the bay; the largest is the Hyperion Treatment Plant (~1.3 10^6 m^3/day). This plant has recently achieved full secondary treatment, and discharges secondary treated wastewater via an 11 km outfall. The second source is a petroleum refinery that has advanced wastewater treatment. Another source is Los Angeles CountyÕs Joint Water Pollut ion Control Plant (~1.3 10^6 m^3/day, ~60% secondary), which discharges outside of the bay, and is upgrading to secondary treatment. Currents carry the partially treated wastewater into the bay.

The improved treatment has decreased pollutant discharge to the bay by more than an order of magnitude during the past 20 years. As a result, non-point sources now contribute an increased fraction of the total pollutant mass to the Bay (Wong *et al.*, 1997). The non-point contribution is already the major source for many pollutants, e.g. heavy metals, and will become the major source for many more pollutants as full secondary treatment is achieved. Reclamation and water conservation will further reduce point source contamination to the bay.

Various agencies, cities and environmental advocacy groups have proposed structural methods for reducing stormwater pollution. These methods are all difficult to employ because they are small-scale solutions that must be applied to a very broad area, across many jurisdictions with varying interests in controlling stormwater pollution. One proposed method for controlling discharges is to use catch basin inserts.

Catch basin inserts are devices that can be placed into a catch basin or stormwater insert, which will in some way reduce pollutant discharge to the receiving water. A variety of devices have been proposed and marketed, but very few have been evaluated by independent sources, or have been used long enough to create a record of performance. In order to establish creditable performance of insert devices, a consortium composed of the Santa Monica Bay Restoration Project and 14 other Santa Monica area jurisdictions funded a two-year study to determine if inserts are a viable method for controlling stormwater pollution. The results of this initial study (WCC, 1998) were sufficiently promising to warrant additional laboratory testing and a field study.

Objectives were established for testing and insert development. These were based in part upon environmental impact of the pollutants, but in greater part upon the ability of a hypothetical device to remove the pollutant in the constrained volume of a catch basin (generally only a few cubic meters). Litter (trash, debris, etc.), particulates and oil and grease were selected as pollutants of concern. Litter was selected because of its interest to regulators and its high visibility with the public. Total Daily Maximum Discharge Limits (TMDLs) will soon be applied to the Santa Monica Bay Watershed, and litter will be among the first. Particulates, as measured by total suspended solids (TSS) are especially important because a large fraction of the heavy metals in stormwater are adsorbed to their surfaces. Oil and grease, especially oil and grease from vehicular areas, is important because it may contain many anthropogenic compounds that may be toxic to aquatic life.

The approach was divided into two parts: dry and wet weather. This was required because of the seasonal rainfall and the desire to collect litter during the long dry period (generally April to November). It was envisioned that controls would be used in dry weather that would be removed in the wet season. Additionally, public agencies were adamant not to increase flood risks. The approximate cost of installation should be no more than US$ 500; cleaning should be infrequently required. A survey of the member cities suggested that, on average, catch basin cleaning occurred no more frequently than once every two months for beach communities, and approximately once per year for Los Angeles County, as a whole. A problem-solving, practical approach was required. The inserts should not increase flood risk and should only marginally change the way stormwater is removed from streets, without increasing the accumulation on streets. Safety considerations such as avoiding confined space entries were important. The public agencies responsible for managing the inserts would soon tire of them if they could not be conveniently, economically and safely maintained.

A sampling program was conducted and differed from previous programs in that samples were collected directly from stormwater on street surfaces, just prior to entry into catch basins. Litter was not measured in the water quality program but was measured during the dry periods as accumulation in the catch basins.

Sampling program

Four locations were selected and sampled during the storm events of the 1997–1998 wet season. This was significant in that it is an El Nino year, and rainfall was at least 200% greater than normal. Table 1 shows the sites and information about them. They were all in the City of Santa Monica and within 4 km of each other.

Samples were taken by scooping 100 to 200 ml at a time until 8 l samples were collected. For short storms only one such sample was collected. For longer storms, three samples were collected and averaged. The oil and grease concentrations were measured by solid phase extraction (Lau and Stenstrom, 1995) and do not include the oil adsorbed to suspended solids. Table 2 shows the mean and standard deviation of conventional water quality parameters for 14 storm events between October 1997 and February 1998. Generally, water quality is worse for Site 1, although the variability tends to make statistical significance

Table 1 Site description

Site number	Land use type	Area (m^2)
1	Commercial (parking lot)	14,000
2	Commercial (streets with small businesses, shops, restaurants, etc.)	7,000
3	Single and multifamily residential	23,000
4	Single and multifamily residential	18,000

Table 2 Stormwater quality (mean followed by standard deviation)

	Concentration							
	Site 1		Site 2		Site 3		Site 4	
Water quality parameter	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.
TSS (mg/l)	55.1	71.6	38.6	32.3	32.7	33.0	34.1	38.2
VSS (mg/l)	38.5	60.5	21.6	14.7	18.5	18.2	18.1	17.7
Turbidity (NTU)	21.2	24.4	14.4	11.3	11.4	8.2	12.0	10.4
Conductivity (mmho/cm)	153.3	199.4	155.2	163.3	180.3	144.2	151.4	146.0
pH	6.4	0.4	6.7	0.4	6.8	0.5	6.9	0.6
Alkalinity (mg/l as $CaCO_3$)	19.1	13.2	22.5	13.0	27.8	16.7	26.0	15.6
Hardness (mg/l as $CaCO_3$)	38.8	42.4	37.8	33.8	41.3	31.1	44.9	41.2
COD (mg/l)	171.7	205.0	100.9	119.3	106.0	102.5	111.3	116.3
SPE oil and grease (mg/l)	7.4	10.3	5.5	5.7	5.3	5.2	5.8	8.0
Ammonia (mg/l as NH_3–N)	1.3	1.1	1.0	1.0	1.6	1.3	0.9	0.8
Cl^- (mg/l)	26.6	36.0	25.6	28.8	24.7	20.9	20.7	19.2
NO_3^- (mg/l as NO_3–N)	0.1	0.2	0.1	0.1	0.3	0.4	0.2	0.2
DOC (mg/l)	40.1	57.1	31.4	44.9	26.8	29.1	26.3	28.8

Av.=average; Std. dev.=standard deviation

Table 3 Selected total metals and percent adsorbed to suspended solids

Metal	Concentration							
	Site 1		Site 2		Site 3		Site 4	
	μg/l	%	μg/l	%	μg/l	%	μg/l	%
Aluminium	2235	96	1141	91	1335	91	678	76
Copper	103	53	42	6	52	8	40	11
Lead	45	93	4	33	7	46	11	17
Nickel	75	83	24	61	38	56	39	71
Zinc	2601	70	2062	63	2377	74	1321	70

%=percentage of particulate phase

Table 4 Size fraction of TSS from site 1

Size distribution (μm)	Distribution (%)
> 150	26
150 – 75	13
75 – 45	11
< 45	50

testing difficult. Trash and debris were not quantified, but trash and debris from the commercial sites was obviously greater. Table 3 shows the results for selected metals (only four storm events), as a total concentration and the distribution that was adsorbed onto the suspended solids. These results tended to confirm that metals were associated with the suspended solids.

Toward the end of the sampling period, various insert devices had been evaluated, and it became apparent that the devices could remove larger particles. Therefore additional sampling was performed to determine the size of the particles that compose the TSS. Site 1 was monitored for three storms and the TSS was determined by bailing several hundred litres of water through sieves. Particle sizes are shown in Table 4. These results suggest, for example, that a device that could remove particles larger than 75 m could remove 39% of the TSS.

Insert evaluation

A survey of all commercially available inserts was performed. At the time of the survey (1997Ð1998), no devices were found that met all the criteria. A number of promising technologies were found that could treat stormwater, but not for the most common catch basin geometry used in greater Los Angeles. After some review, a concept was developed for a basket that could be inserted and removed through the opening of the catch basin, as shown in Figure 1. Several manufacturers offered prototypes featuring this general concept. This device has the advantage of being useful for both dry and wet weather applications. This design has the advantage of easy installation. An insert that is flexible, or is no greater in width than the opening in the curb, can be inserted and removed from the street. Two chains or cables to the curb support the insert. Workers do not need to enter the catch basin, which in some places is considered a confined space. Alternatively, if worker entry to the catch basin is permissible, the inserts can be installed by bolting to the interior wall. Additionally, high flows are directed around the insert, and flood risk is not increased. Additional material including photographs is available elsewhere (WCC, 1998).

The climate in Southern California presents a special opportunity for dry weather control. The litter that accumulates during the spring and summer, if not removed from catch

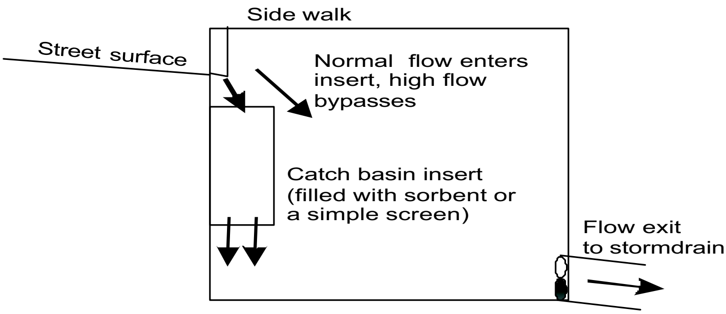

Figure 1 Elevation view of the model catch basin insert developed in this study. Typical minimum basin dimensions are 1 m tall by 0.75 m deep by 1 m wide. The minimum opening is typically 0.15 m

basins, is swept into the bay by the first large storm of the season. To mitigate this problem, the basins are cleaned in September or October. One community has routinely covered catch basins (curbside inlet only) in the dry season to prevent litter build up, insect and rodent problems. Street sweepers then remove the litter, and street sweeping is routinely practiced in these locations. The cover consisted of a plywood board, extending the entire length of catch basin with a gap of 1Ð2 cm between the bottom of the board and the pavement to allow for nuisance water to enter the basin. The covers or ÒboardoversÓ are used only for catch basins in sensitive or high litter-producing areas, and must be removed prior to the rainy season.

To better understand the utility of this practice, two catch basins were covered with plywood and two with wire screens with 2.5 cm square openings. Trash accumulation was monitored. The screens and boards provided roughly equal performance, preventing more than 95% of the build-up in the catch basin, as compared to controls with no covers. Tests were conducted with conventional street sweepers to show that they were capable of removing material that accumulated at the bottom of the covers, and that the sweeper did not destroy the covers. The covers are especially useful in areas with high pedestrian traffic.

Tests to evaluate the insertsÕ ability to remove contaminants from flowing stormwater were conducted in phases at different scales. Bench scale tests, full-scale laboratory tests and field tests were conducted. Field tests were conducted primarily during the second year of the study. The majority of the testing evaluated oil and grease removal. Many commercially available inserts or stormwater treatment devices claimed that sorbents could be used to remove the oil and grease from stormwater. Previous tests by the authors (Lau and Stenstrom, 1995) also suggested that this might be promising.

Tests were first conducted in columns with 5 cm diameter and height of 5 cm, with mixtures of used motor oil (to simulate the oil and grease in stormwater from commercial areas) and tap water using many different types of sorbents. The oil and grease concentration was generally set to approximately 25 mg/l, which is higher than found in this study, but closer to concentrations of oil and grease found in earlier studies by the author (Stenstrom *et al*., 1984; Fam *et al*.,1987). Emulsified oil was produced by intensely blending used motor oil with 1 l of tap water to produce a ÒstockÓ mixture, which was then further diluted when pumped to the column. Free oil and grease was produced by pumping oil and grease using a syringe pump into a mixing ÒteeÓ which was then applied to the columns. The combined flow was allowed to ÒtrickleÓ through the loosely packed column.

Table 5 shows some of the results. The reported efficiencies are for the period when the sorbent remains ÒfreshÓ or unexhausted. As the sorbent is saturated, its efficiency will decline. The mass of adsorbed material per unit mass of sorbent, analogous to ÒQÓ or ÒMÓ for activated carbon isotherms, is an important parameter for overall operation. It

Table 5 Removal efficiencies of various sorbents

Sorbent type	Oil and grease type	Removal efficiency (%)
OARS polymer	Emulsified	3
Activated carbon	Emulsified	11
Aluminium silicate (e.g., perlite, Xsorb)	Emulsified	~0
Straw	Emulsified	~0
Compost	Emulsified	~0
OARS polymer	Free	88, 91
Aluminium silicate (e.g., perlite, Xsorb)	Free	88, 91, 94, 89
Compost	Free	28, 49
Polypropylene (type 1)	Free	86, 92
Polypropylene (type 2)	Free	78, 85

Table 6 Summary of OARS insert device tests

Test no.	Prototype no.	Sorbent condition	Q (l/min)	Influent O&G conc. (mg/L)	Removal efficiency (%)	Final *M*** (g)
A	1	New	56	20.7	91	11
B	2	New	56	14.1	74	6
1	2	Used in the field*	56	8.4	73	40
2	2	Used from test 1	56	24.7	79	172
3	2	Used from test 2	132	10.7	62	275
4	3	New	132	19.0	78	233
5	3	Used from test 4	132	14.0	65	374
6	3	Used from test 5	132	10.9	46	452
				Inf. TSS (mg/l)		Mesh size
8	3	From test 6		66	99	40
				66	96	60
				66	78	100
				200	91	Average
				PAHs (nominal conc. 50 μg/l)		
9	3	New		Acenapthene	34	
				Fluorene	31	
				Phenanthrene	33	
				Anthracene	61	
				Fluoranthene	33	
				Pyrene	42	
				Chrysene	26	
				Benzo(a)pyrene	16	

* does not include oil and grease removed in the field;
** M = total mass of O&G absorbed (g)

determines the sorbent replacement frequency and therefore the economics of operation. Further work in our laboratory is ongoing to determine these parameters. The sorbents shown in Table 5 are similar, or very similar, to commercially marketed products. The polypropylene materials are used in oil spill control pads and booms. The straw is also used for oil spill clean-up.

None of the sorbents was effective in removing the emulsified oil and grease in this type of experiment. The polypropylene sorbents were evaluated in other tests with 8 to 12 hour contact times and were able to remove 40% to 60% of the oil and grease. If tightly packed into columns, they will remove emulsified oil and grease from waters pumped through under high pressure, but this filtration procedure is not economically feasible for stormwater.

A new series of tests was performed in the full-scale catch basin simulator. This simulator is composed of a stilling chamber, a 0.6 m wide flume that simulates street surface, and a catch basin with a 0.9 m wide opening. Contaminants are released into the flume at controlled rates to produce the desired concentrations. Tap water is used for stormwater. This size is the same as the smallest catch basin routinely constructed by the Los Angeles County Department of Public Works. It was constructed of plywood and cement and built above grade to allow easy access. The 0.9 m opening could accommodate a variety of types of inserts. The inserts were temporarily clamped to the walls of the catchbasin and were easily changed and refitted, as needed.

Two prototype designs were extensively tested. The first used OARS sorbent, which was placed in metal boxes with open tops and screened bottoms. Stormwater flows from the top, through the OARS sorbent, which has a particle size from 5Ð30 mm with a density of 0.22 g/ml (our measurements, not the manufacturersÕ specificati ons). The internal arrangement of the box traps suspended solids and trash. This allows the box to perform as oil and grease, suspended solids, and trash removal device. It also means that in installations where high trash and suspended solids are present, the box may clog before the oil sorption capacity is reached. The second insert extensively tested used polypropylene cloth as a sorption/filtration media. The cloth is supported by a geotextile used for stabilizing soils. The cloth is available in different weights. The geotextile has openings of approximately 1 cm by 8 cm. The prototype inserts have a metal collar at the top, which forms the support for the geotextile. The insert is flexible and can be compressed for insertion though an opening smaller than its height. This design has all the previously cited advantages, and can also be easily constructed in custom sizes.

Tables 6 and 7 show the results for both sorbents. The oil and grease removal efficiency ranged from 40% to more than 90%, depending upon sorbent condition and influent concentration. Removal efficiency was generally higher with higher influent concentrations. The media used in tests 1 and 2 for OARS had been used in the field for four months and represented partially used sorbent. Several tests (Figures 2 and 3) were conducted using the same media, in an attempt to exhaust the media.

Also shown in Tables 6 and 7 are test results for TSS and PAH removal. For the case of TSS, sand particles were sieved and recombined to produce an evenly divided mixture, by mass of sand with US standard meshes of 40, 60, and 100 (approximately 400 to 120 m). The box removed 99% of the large particles and 78% of the smallest particles. PAH removal was measured by spiking tap water with known masses of PAHs and then measuring effluent concentrations. The removal efficiency ranged from 16% to 61%. Again, the total capacity of the insert was not determined, so the mass of solids or PAHs that can be removed before maintenance is not known. This is the subject of further testing in our laboratory, and should be evaluated in the field as well.

Field tests

Field tests were conducted in the second year of the project at commercial and residential sites. Six sites were initially selected. Three used the polypropylene style insert (two in commercial areas) with double thickness liners, two used the OARS containing insert (one in a commercial area), and one used a simple wire mesh basket (~1 cm opening, in a residential area) with no sorbent or filter media. The inserts were observed to bypass flow at the greatest runoff condition and gradually bypassed more flow as they became clogged. After about two months of active rainfall, the bypassing became more frequent and the polypropylene sorbents were replaced with medium screens (see test 14 in Table 7).

Table 7 Summary of a polypropylene insert device tests

Test no.	Liner type	Sorbent condition	Q (l/min)	Influent O&G conc. (mg/l)	Removal efficiency (%)	Final *M** (g)
1	12 oz	New	473	13.5	65	121
2	12 oz	New	283	28.8	82	200
3	12 oz	New	56	37.0	86	54
4	12 oz	New	720	12.7	53	145
5	12 oz	used from test no. 2	283	26.3	78	569
6	12 oz	used from test no. 5	283	21.4	79	714
7	12 oz	used from test no. 6	283	30.2	70	1400
8	12 oz	used from test no. 7	283	23.9	58	2058
9	12 oz	New	283	8.1	56	157
10	12 oz	New	283	17.6	63	366
11	12 oz	New	283	30.5	59	578
12	8 oz	New	283	8.1	49	133
13	Double bag	New	283	11.0	74	274
				TSS (mg/L)		Mesh size
14	Screen	New	283	66	34	40
				66	2	60
				66	0	100
				200	12	Average
15	12 oz	New	283	66	98	40
				66	96	60
				66	95	100
				200	96	Average
				PAHs (50 ug/l)		
16	Double bag	used from test 13		Acenapthene	55	
				Fluorene	51	
				Phenanthrene	58	
				Anthracene	88	
				Fluoranthene	61	
				Pyrene	56	
				Chrysene	82	
				Benzo(a)pyrene	69	

*M = total mass of O&G absorbed (g)

Testing ended for the OARS type sorbents. When stormwater bypassed the insert, there was no change in street runoff rate or increased accumulation on the street surface; the clogged insert had no impact on stormwater removal rate from the street. Sampling was performed as before, except that effluent samples were also collected.

Each residential site was ~12,000 m^2 in area, and the three commercial sites had areas ~5000 m^2 each. Table 8 shows the average water quality for the second year of the study. The values are similar to those shown in Table 2. The standard deviations are high, which is typical for stormwater. Site 2 in Table 2 is similar to the commercial sites used in the second year. The residential sites in the two studies are similar in land use and housing density. The high standard deviations mask water quality comparisons; however, turbidity, COD, DOC, chloride, SPE oil and grease and are higher in the commercial sites (one-tailed test at = 0.15).

The water quality data shown in Table 8 serves as the influent for an efficiency test of the inserts. Effluent samples were collected from the insert using a cup on a stick. Samples were collected when the inserts were not bypassing. Removals for the polypropylene insert

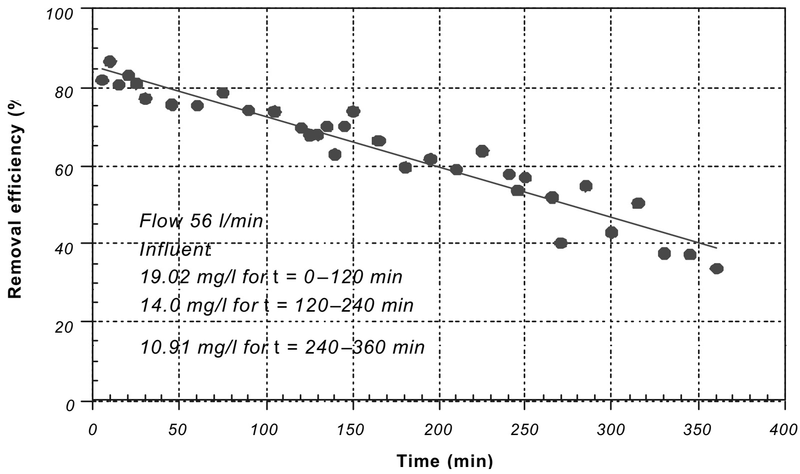

Figure 2 Oil and grease removal efficiency versus time for an insert using OARS sorbent

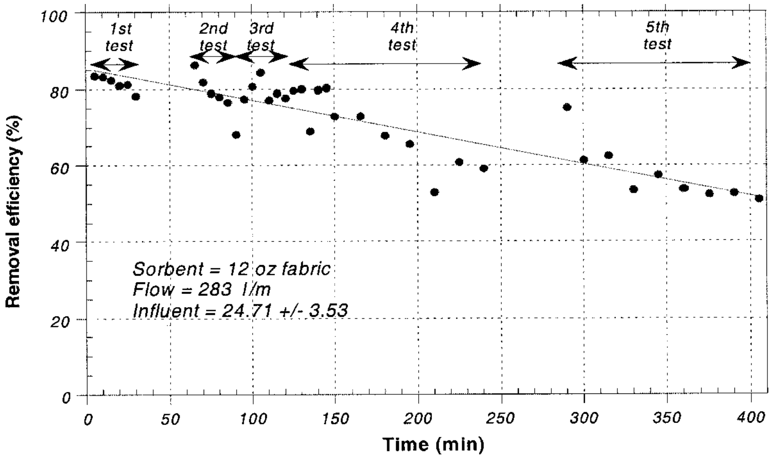

Figure 3 Oil and grease removal efficiency versus time for an insert using polypropylene sorbent

averaged 21, 36 and 34% for TSS, VSS and turbidity, respectively. The OARS device averaged 21, 9 and 12% for the same parameters. The variability in oil and grease removal rates precludes making any conclusion. Table 4 suggested that 26% of the sediment in stormwater might be removed by a filter that captures solids greater than 150 m. The removals in actual field test are below this prediction, but are not too much different, especially considering the highly variable nature of stormwater. The TSS procedure captures 100% of all particles greater than 0.8 m; the majority of the material that composes suspended solids is less than the size that can be removed by insert filters.

At the end of the study, the polypropylene bags and screens were removed and the contents were air dried. The material smaller than 12,700 m (0.5 in) was weighted, screened and reweighed. Table 9 shows the results from the first part of the study. The inserts at the two commercial sites tended to recover smaller particles. Table 10 shows the results for the second part of the study. This study used a much coarser mesh screen, but still recovered many small particles. Again, there is much more finer material at the commercial sites.

The final data reduction was to calculate an equivalent concentration of captured material per unit of runoff volume. This is similar to an event mean concentration, in that the total runoff volume can be multiplied by the coefficients to produce an expected mass of

Table 8 Water quality parameters for the second year. Number of observations = 16 for commercial sites and 14 for residential sites

Water quality parameter	Commercial Mean	Commercial Std. dev.	Residential Mean	Residential Std. dev.
TSS (mg/l)	54.9	41.7	43.2	39.4
VSS (mg/l)	23.5	18.4	20.0	15.7
Turbidity (NTU)	32.5	23.7	15.6	10.0
Conductivity (mmho/cm)	136.5	95.1	118.8	61.8
pH	6.9	1.1	7.1	0.8
Alkalinity (mg/l as $CaCO_3$)	27.4	22.0	28.7	16.7
Hardness (mg/l as $CaCO_3$)	37.9	29.5	35.9	17.5
COD (mg/l)	147.6	113.5	103.6	66.7
DOC (mg/l)	36.4	33.0	22.9	11.5
SPE Oil and Grease (mg/l)	16.6	21.7	5.4	3.5
Ammonia (mg/l as NH_3–N)	1.1	2.1	0.5	0.6
Cl^- (mg/l)	13.7	10.4	7.2	6.0
NO_2^- (mg/l as NO_2–N)	0.1	0.1	0.1	0.0
NO_3^- (mg/l as NO_3–N)	0.7	0.6	0.7	0.4
SO_4^{2-} (mg/l)	9.3	9.6	7.3	4.7

Table 9 Sieve results for the first part of the study

Sieve opening (µm)	Percentage finer than based on total sample: Commercial 1	Commercial 2	Residential
12,700	100.0	100.0	100.0
6,350	56.6	69.0	93.4
3,175	38.2	57.1	82.6
1,999	24.1	40.5	64.3
841	23.5	39.8	60.5
419	15.5	24.9	32.8
249	10.8	14.6	14.8
150	7.6	8.9	5.5
74	4.8	4.4	1.9
Pan	2.2	1.2	0.6

Table 10 Sieve results for the second part of the study

Sieve opening (µm)	Percentage finer than based on total sample							
	Commercial 1					Residential 1		
	1	2	3	4	5	1	2	3
12,700	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6,350	49.7	42.4	33.9	79.6	65.9	97.0	49.1	29.8
3,175	38.5	32.8	25.5	66.7	55.1	89.5	31.1	19.1
1,999	25.1	24.3	19.1	53.4	44.9	76.0	20.8	11.0
841	24.1	23.3	18.9	51.0	37.3	72.3	19.7	10.6
419	13.3	21.3	14.7	30.3	20.1	43.6	9.4	7.1
249	7.2	17.8	10.4	14.2	15.6	17.8	3.3	3.9
178	3.7	12.4	7.4	5.8	9.7	6.3	1.2	1.8
150	2.2	8.5	5.9	3.2	6.3	2.8	0.5	1.0
74	1.6	6.5	5.0	2.3	4.7	1.6	0.3	0.7
Pan	0.5	2.1	2.6	0.8	1.3	0.3	0.1	0.2

Table 11 Unit loading rates of collected material (kg/m^3 of runoff)

Size (μm)	Commercial 1	Commercial 2	Commercial 3	Commercial 4	Commercial 5	Residential 1	Residential 2	Residential 3
> 12,700	0.92	1.24	2.06	0.68	0.82	0.62	0.17	0.11
12,7000 – 6,350	0.20	0.21	0.26	0.43	0.26	0.22	0.03	0.28
6,350 – 3,175	0.25	0.18	0.20	0.44	0.24	0.13	0.02	0.50
< 3,750	0.46	0.52	0.60	1.79	1.08	0.25	0.03	2.84
Total	**1.83**	**2.15**	**3.12**	**3.34**	**2.40**	**1.22**	**0.25**	**3.73**

captured litter and particles. Table 11 shows these results. The coefficients are shown in units of kg/m^3. Note that the solids larger than 12,700 μm are included. These coefficients were calculated using the catchment area for each site, rainfall observed during the study, and runoff coefficients of 0.39 for residential and 0.6–0.7 for commercial sites. These totals include material swept or blown into the catch basin during non-rainy periods, which in Southern California is the majority of the time. The coefficients in Table 11 will have two systematic errors. The coefficients will be lower than the actual load, since the insert devices are imperfect and bypass at high flow. The coefficients are higher than the actual load carried by stormwater, due to the flux of material in dry weather. The coefficients can be used as a first-order approximation of the litter and debris to be expected from commercial and residential sites in urban areas in climates similar to Los Angeles.

Conclusions

This manuscript has briefly described the results of laboratory and field tests to determine the opportunities for using catch basin inserts to remove specific pollutants (oil and grease, litter and suspended solids). The inserts have the advantage of using the existing urban infrastructure to remove stormwater pollutants at low cost. The estimated cost of each insert is less than US$ 500. An insert design has been proposed that is easy to install and does not require workers to enter the catch basin. Observations during storms showed that they do not create flooding problems, even when they are clogged. Laboratory testing has showed that free oil and grease (simulated by used automobile crankcase oil) can be removed by a variety of sorbents in simple flow-through contacters. Emulsified oil can generally not be removed. Oil and grease removal in field tests was inconclusive. Laboratory testing showed that particles can be removed down to a size of 100 μm, and field results showed that much smaller particles can also be trapped. Laboratory testing showed that the sorbents can remove dissolved PAHs with efficiencies ranging from 16 to 88%. Additional testing is needed to further demonstrate the utility of these inserts. The removal capacities for oil and grease and suspended solids, which will dictate maintenance frequency and cost, need to be determined. The results presented in this paper are preliminary and should be applied with caution. The authors hope that they will stimulate others to develop catch basin insert technology.

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