Article 111

Technical Note #87 from Watershed Protection Techniques. 2(3): 11-13

Multi-Chamber Treatment Train Developed for Stormwater Hot Spots

Stormwater runoff from paved urban “hot spots,” particularly automotive service and repair stations, can contain pollutant concentrations three to 600 times greater than those found in other urban sources. The higher potential for heavy stormwater pollutant loading becomes apparent when one also considers the multitude of potential hot spots located throughout urban areas (Table 1). This being the case, it becomes prudent to treat a relatively small amount of runoff at the source as opposed to allowing contaminated runoff to become part of a much larger volume that may or may not be effectively treated at the end of the pipe.

Effective, on-site treatment of stormwater hot spots has been a problem for several reasons. First, most hot spots tend to be small in size and lack adequate space for the installation of typical stormwater management practices such as ponds and wetlands. Second, the use of gravitational settling as a sole pollutant removal mechanism does not provide sufficient hot spot pollutant removal. Third, infiltration is not an option due to risks of groundwater contamination. Lastly, the traditional underground approaches using oil grit separators have not been reported to be effective (Schueler, 1994).

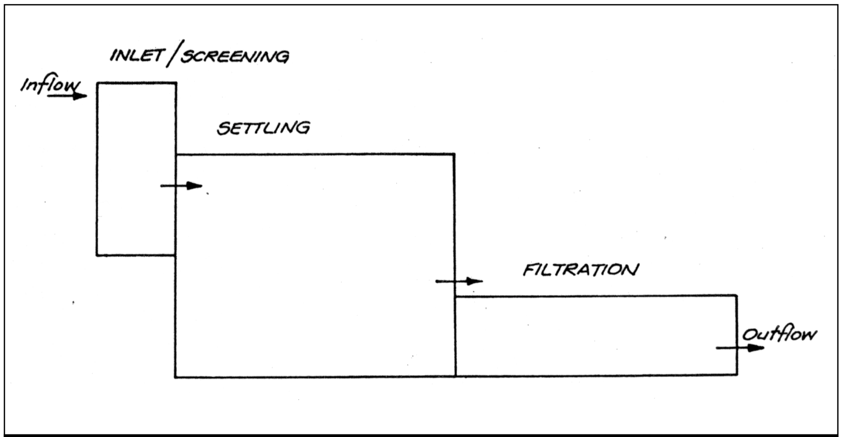


Figure 1: Three Main Chambers of the MCTT

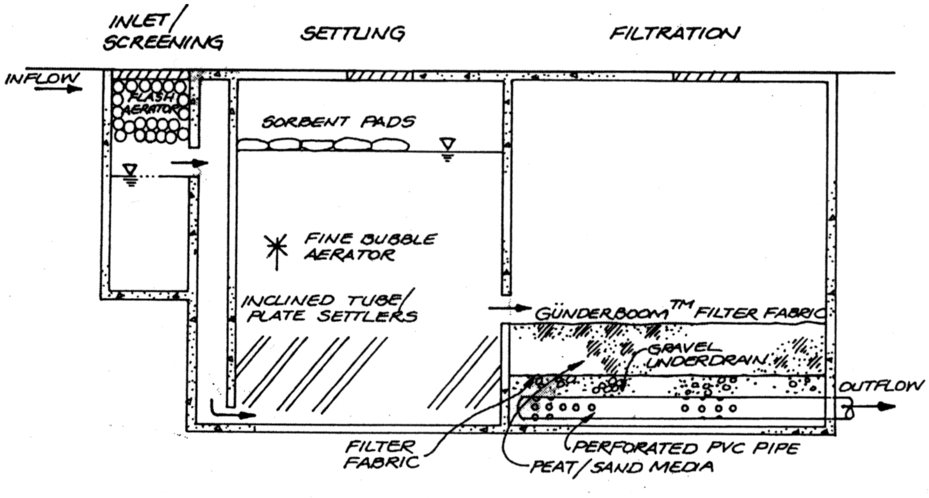
To help solve the hot spot treatment problem, Robert Pitt and his colleagues at the University of Alabama-Birmingham have developed and tested a prototype known as the multi-chambered treatment train (MCTT). This device employs screening in the first chamber, settling in the next, and filtration in the last (Figure 1). It is designed for underground use. It can be sized to contain runoff from various rain events and typically requires between 0.5 and 1.5% of the paved drainage area. Present information places construction costs of the MCTT ranging from $10,000 to $20,000 per one-quarter acre of drainage area, assuming use and availability of prefabricated units (Pitt, personal com-

Table 1: Potential Stormwater Hot Spots
(Schueler, 1996)

- Commercial nursery
- Auto recycle facilities
- Commercial parking lots
- Fueling stations
- Fleet storage areas
- Industrial rooftops
- Marinas
- Outdoor container storage of liquids
- Outdoor loading/unloading facilities
- Public works storage areas
- SARA Title III Section 312 hazmat generators (if containers are exposed to rainfall)
- Vehicle service and maintenance areas
- Vehicle and equipment washing/steam cleaning facilities

Table 2: Specialized Components of the MCTT

Chamber	Component	Description	Function
Inlet	flash aerator	small column packing balls with counter current air flow	removes volatile pollutants and traps trash
	catch basin sump	conventional catch basin sump	traps grit and sand-size particles
Settling	sorbent pads	floating absorbent pads	traps oil and grease
	fine bubble aerator	generator powered fish farm aeration stone	enhances aeration
	inclined tube or plate settlers	plastic tubes 2” x 2’, inclined 30-45 degrees, arranged in rows ofopposing direction	increases surfaces area of settling chamber; enhances sedimentation and prevents scour
Filtration	Gunderboom™ filter fabric	covers top of filter	reduces channelization, slows infiltration, sorbs oils
	peat/sand filter media	50/50 mix, at least 12” depth	removes small and dissolved particles, provides ion exchange
	filter fabric	separates peat/sand layer from gravel and pipe layer	prevents gravel layer from clogging
	gravel packed under drain	perforated PVC pipe and gravel	provides additional filtration/outlet



The multi-chamber treatment train (MCTT) consists of three treatment units in sequence—an inlet screening chamber, a sedimentation chamber and a filtration chamber. Most of the high pollutant removal occurs in the last two chambers.

Figure 2: Detailed Schematic of the MCTT

munication). Additional data on operation and maintenance costs of the MCTT is currently being collected.

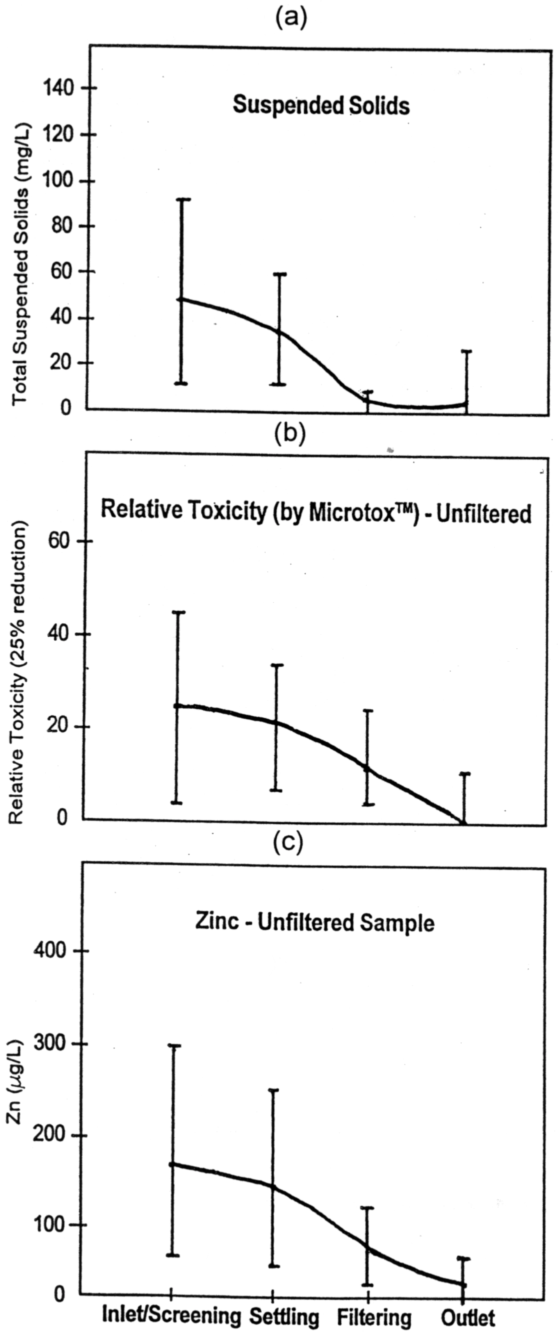
The MCTT is divided into three main chambers (Figure 2). Stormwater enters the first chamber where the largest particulates are screened out and the bulk of highly volatile materials are removed when they pass over a flash aerator (additional, innovative components within each chamber are listed in Table 2). The stormwater then either flows under gravity or is pumped into the settling chamber. Here, settling of fine sediment is enhanced through the use of inclined tube or plate settlers while floating hydrocarbons and additional volatile compounds are removed by sorbent pads and bubble diffusers. Next, the stormwater flows, or is pumped slowly into, the filtration chamber containing a sand and peat filter bed for final removal of dissolved toxicants. The filter also functions in the partial treatment of runoff that may have bypassed prior chambers in the event of excess stormwater flow. To ensure that the water volume is distributed evenly over the filter bed, a fabric covers the top of the filter.

The size of this device varies according to the climatic conditions of the geographic region being served. Parameters considered include: rainfall amount, intensity, and elapsed time between storms as well as suspended sediment load and desired maintenance regime. Pitt has developed a computer model to aid in the site-specific design.

A pilot-scale MCTT was constructed by Pitt on the campus of the University of Alabama- Birmingham. This device, designed to catch runoff from a vehicle service area and parking facility, was tested over a six-month monitoring period from May to October of 1994. Two additional full-scale units have since been constructed in Wisconsin for testing how this technology functions in a colder climate. Preliminary pollutant removal data from the Wisconsin site is presented in Table 4.

Preliminary performance results of the pilot-scale MCTT for 13 storm events indicate substantial reductions of total suspended solids, heavy metals, and both dissolved and suspended stormwater toxicity from the unit overall (Table 4). Toxicity values were obtained using a Microtox™ screen that analyzes specific toxins in both dissolved and suspended forms. This test not only detects nonconventional pollutants in stormwater but establishes a standard by which to measure their "treatability."

Of notable significance is the inlet chamber where screening occurs. Screening has little effect on pollutant removal (it has virtually none) but serves an important role in trapping large materials, thereby reducing problematic maintenance concerns throughout the device and enhancing the ability of other chambers to remove pollutants.



Depending on the nature of the pollutant, the MCTT provides greatest removal in the settling chamber (panel a) or the filtration chamber (panel b and c).

Figure 3: MCTT Pollutant Removal Profile by Chamber

Table 3: Prototype (Alabama) MCTT Pollutant Removal Efficiency Rates Based on Concentration Changes from Inflow to Outflow

Pollutant	Screening Chamber	Settling Chamber	Filtration Chamber	Overall Performance
TSS	nsd*	91	-44	83
Turbidity	(some reduction)	50	-150	40
COD	nsd	56	-24	60
Nitrate	nsd	27	-5	14
Ammonia	nsd	-155	-7	-400
Phosphate	nsd	nsd	1c	-
Toxicity (suspended)	nsd	18	70	96
Toxicity (dissolved)	nsd	64	43	98
Lead	nsd	89	38	100
Zinc	nsd	39	62	91
n-Nitro-di-n-propylamine	nsd	82	100	100
Pyrene	nsd	100	NA	100
bis (2-ethylhexy) phthalate	nsd	99	-190	99

*nsd = inflow and outflow concentrations were not significantly different at the 0.05 level

The settling chamber was responsible for most of the pollutant reductions in suspended solids, lead, zinc, polycyclic aromatic hydrocarbons (PAHs), turbidity, COD and to a lesser degree, nitrate and toxicity. The filter chamber provided additional removal of most toxicity and heavy metals. Ammonia nitrogen was increased by several times and nitrate-nitrogen had a very low removal rate. However, this finding is to be expected given the anaerobic nature of the filter system.

Preliminary monitoring data from two full-scale application of the MCTT in Wisconsin appear to confirm that it can achieve consistently high removal for solids, nutrients, metals and two polycyclic aromatic hydrocarbon (see Table 4). The Wisconsin test sites involved a similar design that treated stormwater runoff from a quarter-acre maintenance yard and a newly paved parking lot.

Based on the initial monitoring of the prototype and full-scale system, it appears that the design provides superior performance to conventional sand filter systems (see Table 4), which is reasonable considering that the sand filters employ much less sophisticated measures for screening, settling and filtration.

Pitt's study design was arranged to isolate the relative contribution of each of the three chambers—screening, settling and filtration—to the overall pollutant removal of the system (Figure 3). Pitt found that the importance of each chamber depended on the type of pollutant entering the system. For example, many suspended pollutants were removed quite efficiently using just the settling process, whereas the filtration chamber was responsible for further reduction of those same pollutants as well as the additional removal of dissolved pollutants. Suspended solids were reduced somewhat by screening but were almost totally reduced by settling while filtration was of no consequence (Figure 3, panel a).

Toxicity was basically unaffected by screening, received slight treatment in the settling chamber but was reduced significantly by filtration. This comparison is a clear illustration of the relative importance of settling versus filtration for certain types of pollutants. As shown in panel c of Figure 3, screening accomplished in the inlet chamber only achieved negligible zinc reductions. Pollutant removal was attained through settling followed by more extensive removal from filtration.

Further analysis of MCTT pollutant removal capabilities may be obtained through testing the efficiencies of the innovative components within each chamber and the effects they have on improving and enhancing the three processes of screening, settling and filtration. Given variable climates and pollutant concentrations present at hot spots, a full application of the MCTT may only be needed when a very high level of treatment is desired.

—TJL

Table 4: Preliminary Pollutant Removal Efficiency for Two Full-Scale Multi-Chamber Treatment Train (MCTT) Systems in Wisconsin

	Ruby Street MCTT[1]	Minoqua MCTT[2]	Sand Filters Mean[3]
No. of Storms [4]	5-6	7	226
	Pollutant Removal (%)		
Suspended Solids	98	85	85
Total Phosphorous	84	80	50
Total Zinc	93	90	71
Total Copper	89	65	43
Flouranthene	92	>90	no data
Pyrene	>80	>75	no data

[1] Full-scale MCTT installed in Ruby Street Garage in Milwaukee, Wisconsin, that treats runoff from maintenance garage (drainage are 0.25 acres). Pollutant removal computed in total load bases. (Data from Corsi and Greb, personal communication).

[2] Full-scale MCTT installed at 2.5 acre new commercial parking lot. Pollutant removal computed on median EMC removal method. Data from Pitt (1996).

[3] Mean removal efficiency of 12 independent monitoring studies analyzed in Claytor and Schueler (1996).

[4] Number of paired storm events sampled.

References

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