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Study Quantifies Broom Sweeper Litter Pickup Ability

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Study Quantifies Broom Sweeper Litter Pickup Ability

by Gary Lippner, PE and Glenn Moeller, PE

The Los Angeles Regional Water Quality Control Board has drafted a total maximum daily load (TMDL) for litter in the Los Angeles River watershed. There will be two years of baseline monitoring, followed by 10 years of reductions in the allowed load discharged until a requirement of zero litter discharge by the year 2012.

Although there is ample information regarding roadside litter, little exists regarding litter discharges from storm drain systems. The recently completed Litter Management Pilot Study addresses this shortcoming. The focus of the study was to assess the effectiveness of various Best Management Practices (BMPs), both structural and non-structural, in their ability to reduce the litter discharged from the freeway storm drain system in the Los Angeles area. The non-structural BMPs included street sweeping and a litter pickup program similar to the California Department of Transportation (Caltrans) Adopt-AHighway program. In contrast, the structural BMPs were modified drain inlet grates, for example converting a standard inlet grate into a curb-cut drain with a flap gate. This article will cover the litter reduction potential of a particular type of street sweeper, one that uses a mechanical broom pickup system.

Because the focus of this study was freeway litter, the study included field-tests of vacuum, regenerative air, high-efficiency and mechanical broom sweepers to determine which sweeper type would be most appropriate. Currently, some believe that highefficiency and/or regenerative air sweepers remove some pollutants more effectively than do broom sweepers (e.g., small-micron, or PM-10 particulates). One problem discovered with the regenerative air sweepers was that large material lodged in their air intake hoses even though the hose openings are typically 12”-to-14” wide. However, other sweeper types did appear to leave the pavement cleaner than did the broom sweepers. Another problem was that large material got in front of the suction head of the air machines and the sweeper pushed it along rather than sucking it up. Then, when the sweeper went over a drain inlet the material fell into the drain. This ‘snow plow’ effect also occurred with the mechanical broom sweepers. However, our review during the preliminary field test showed the effect was much more prevalent with the air-type sweepers. The effect may be less problematic if pickup systems were employed in tandem. For example, if there were a litter pickup person in the front for the very large items, followed by a broom sweeper or regenerative air sweeper.

The high-efficiency sweeper had a completely different problem. Caltrans freeway sweepers must be able to travel at freeway speeds while traveling to the sweeping site. The high-efficiency sweeper we examined, a Schwarze EV-series machine, was not available mounted on a standard truck chassis. The machine’s maximum operating speed precluded it being used in a Caltrans freeway application. With a change to standard chassis mounting, however, that type of technology would become available for freeway use. Transporting the sweeper via truck and trailer, and unloading and loading the sweeper on the side of the freeway to sweep the short roadway segments used in this study, was deemed impractical.

We decided to use a Mobil model M-8A broom sweeper for this study. This sweeper is typical of the type of machines currently used to sweep California freeways, and this would minimize the

problems mentioned earlier. An example of the machine used is shown in Figure 1. The intent of the study was to determine if varying sweeping frequency would affect drainage system litter discharges. The Caltrans maintenance manual schedules sweeping such that the sweepers remove approximately one-half to one cubic yard of material per linear mile. This results in sweeping roughly once per month. This frequency was compared to weekly sweeping to determine the effect on litter discharges.

Figure 1. Mobil sweeper used for the Litter Management Pilot Study

The study was conducted via a paired watershed study. The monthly sweeping was done in one watershed, with the end-of-pipe discharges compared to the discharges from a similar watershed swept weekly. For manageability, all the watersheds selected were less than 1 acre. We monitored a total of six watersheds, three for the control and three for the enhanced BMP, resulting in a triple replicate paired watershed study.

Figure 2. Litter sampling device

Because there is no standard, accepted method for monitoring litter, we had to devise a monitoring method to collect the litter. Ultimately, we captured the litter that came through the storm drain system in 1/4" mesh bags attached to the outfall pipe (shown in Figure 2). We also checked to see if a correlation existed between conventional water quality parameters (metals, nutrients, etc.) and the litter concentration. To accomplish this, one of the three pairs was outfitted for conventional water quality sampling, including rain gauges, flow meters, and autosamplers. The study was conducted for two rainy seasons (October of 1998 to April of 2000), during which we captured a total of approximately 21 storms.

Unfortunately, no correlation between the amount of litter discharged and the chemical constituents was apparent. This could be because of the limited number of data points or because no correlation actually exists. A couple of general things were noted about litter. First, the material discharged from the drainage system was generally small. Our initial protocols called for separate analysis of litter between 1/4 inch and 1 inch, between 1 and 4 inches, and larger than 4 inches. However, since most of the litter discharged was less than 1-1/2 inches, we ended up with just one size category. We believe this is primarily due to the drain inlet grates' spacing of 1-1/2 inches on center. This shows that drain inlet grates are very effective at inhibiting larger litter from getting into the drain inlets themselves. Figure 3 shows typical litter that was discharged being sorted.

Figure 3. Typically discharged litter being sorted

Another interesting outcome was that the study really examined all gross pollutants present (i.e., litter and vegetative material). We learned that a large amount of vegetation was discharged along with the litter. We found that total end-of-pipe load, by weight or volume, was 60-90% vegetation. This vegetative load must be considered during any BMP monitoring or design.

Like litter monitoring, there was little consensus in the literature about how to characterize the discharged litter, whether analysis should be based on volume, weight, or unit count. We did all three. We also normalized the data by catchment area and runoff volume. We found that weight and volume often have similar patterns. For example, cardboard, paper, plastic and Styrofoam make up almost half of the litter by both weight and volume. But, a different pattern is observed when characterizing litter by item count. By count, the single most prevalent item is cigarette butts, being about 35% of the items counted.

One other question was how much of the litter floats. To determine this, we placed litter on a tub of water, stirred it, and then collected the amount of litter from the top and called that "highly floatable." The other we called "settleable litter." By volume, about 80% of the litter were highly floatable. This technique is of questionable worth though, because it is very difficult to mimic hydraulic turbulence and other real world conditions in a laboratory setting. As a result, the method probably overestimated the floatable litter fraction.

We compared the results of sweeping monthly vs. weekly by looking at weight, volume and count. We considered the BMP to be effective if the reduction was statistically significant at the 95% level. The analysis indicated that the reduction of litter discharged was not statistically significant. In fact, there were several cases where sweeping weekly actually elevated the amount of litter discharge from the drainage system. Conventional water quality constituents such as metals, nutrients, oil and grease, total suspended solids, and coliform bacteria were also examined. The results indicate that increasing sweeping from monthly to weekly actually increased the concentrations of hardness, total and dissolved copper, dissolved nickel, and total petroleum hydrocarbons (diesel). So, one thing we learned was that increasing the frequency of this type of sweeping from monthly to weekly had the potential to increase the concentration of metals discharged.

(Editor's note: In terms of all the BMPs tested, which did not include a regenerative air or Schwarze EV high-efficiency sweeper, the BMP that seemed to work best was the Adopt- A-Highway program. It decreased litter from 30-40%, depending on whether analysis considered weight, volume or count. Second most effective was a modified drain inlet grate where a perforated plate was welded on the upstream quarter of the drain inlet grate. That reduced litter about 20-25%, depending upon method of analysis.)

This study found that increasing the frequency of freeway sweeper operations from monthly to weekly does not appear to reduce the concentration of litter discharged from the freeway drainage system. However, sweeping did remove substantial litter from the freeway right-of-way. Additionally, this study advanced the state-of-the-art of monitoring and characterization techniques for litter in stormwater.

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