United States
Environmental Protection
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Storm Water Technology Fact Sheet

Sorbent Materials in Storm Water Applications

DESCRIPTION

Sorbent materials (which include absorbents and adsorbents) have specific physical and/or chemical properties that allow them to attract specific types of liquids and/or gases. Absorbents and adsorbents function in different ways. In general, absorbent materials attract compounds into their pore spaces; adsorbents attract materials to their surfaces but do not allow them to penetrate into their pore spaces (U.S. EPA, accessed 2000). The American Society of Testing and Materials (ASTM) has defined absorption by absorbent materials as "a process where the material taken is distributed throughout the body of the absorbing material." Adsorption is "a process where the material taken is distributed over the surface of the adsorbing material." Both processes can essentially "capture" sorbed materials, concentrating them or removing them from solution. Thus, either process allows captured materials to be more easily removed from a media.

Recent research has shown that sorbent materials can be used in storm water applications to remove oil and grease (O&G). High concentrations of O&G can cause toxicity in receiving waters, and most discharge regulations require that there be no discharge of oily wastes that produce a sheen on the surface of the receiving water.

Sources of oil and grease in storm water include O&G sorbed to trash and other debris; O&G sorbed to particulates; emulsified oils (small drops of oil suspended in storm water); free floating oil; and suspended oil (CDS Technologies, 2000, literature provided by manufacturer). Research shows that between 83 and 98 percent of total hydrocarbons in storm water runoff are associated with particulate matter, and evidence suggests that a significant portion of these particles are settleable solids, such as sediments (Hoffman, et. al., 1982). Therefore, storm water Best Management Practices (BMPs) designed to remove sediments may also remove some oil and grease associated with the sediments.

Typically, only free-floating oil concentrations are measured and reported in storm water studies (CDS Technologies, Inc., 2000). Concentrations of free floating oil and grease typically range between 10-35 mg/L for urban storm water runoff (U.S. EPA, 1999a), although concentrations can vary widely and are dependent on catchment characteristics (Hoffman, et al., 1982; and Stenstrom, et al., 1984).

Because the specific gravity of free floating O&G is lower than that of O&G sorbed to sediments, it can be difficult to remove through traditional gravity separation BMPs. Storm water BMPs such as oil/water separators are designed to reduce influent flow rates, which enhances gravity separation of oil and water over the length of the unit. The use of coalescing plates may further enhance oil/water separation. However, these systems must retain relatively large volumes of storm water in order to function effectively, and therefore they may not be practical where space is limited. Therefore, many BMPs are designed specifically to remove these hydrocarbons through higher-rate physical interactions.

One method for removing free floating oils and grease from storm water is through the use of sorbent materials. Sorbent materials have traditionally been used to clean up spills, such as for soaking up fuel spilled on a roadway. More recently, however, sorbent materials have been incorporated into storm water BMPs to improve water quality from storm water runoff. Sorbent materials are currently being utilized within BMPs placed in storm water catch basins, sumps, or other parts of a storm sewer system to capture hydrocarbons and other toxic chemicals and prevent them from being carried through the storm water system.

APPLICABILITY

Sorbent materials are usually used in areas where storm water runoff is likely to have a high amount of oil and grease. Because much of the oil and grease in urban storm water originates from motor vehicles, through engine drippings, exhaust, and maintenance activities, most storm water BMPs using sorbent materials are placed near roadways, parking areas, and service stations (Hoffman, et al., 1982; and Stenstrom, et al., 1984).

Sorbent materials are diverse, allowing them to be utilized in several different types of BMP applications, including new and retrofit applications. While many vendors market sorbent materials, relatively few sorbent manufacturers have developed and marketed materials to remove oil and grease from storm water. This Fact Sheet discusses only those sorbents currently used in storm water BMPs.

ADVANTAGES AND DISADVANTAGES

Listed below are some of the advantages and disadvantages of using sorbent materials to remove oil and grease in storm water BMPs.

Advantages

- Sorbent materials can be applied to a variety of storm water applications. There are numerous types of natural and manufactured sorbents and a wide range of BMPs that use them, including catch basin and curb inlet inserts, skimmers, and filters. These BMPs can be applied at almost any point in a storm system, and can be retrofitted into an existing system or installed into a new system.

- Many units are easily installed because they do not require specialized equipment. For example, the OARS® Passive Skimmer is hung on hooks from a manhole cover; DrainGuard™ products are suspended from a geotextile fabric that can be stretched underneath a grate over a catch basin or a curb inlet.

- Storm water BMPs using sorbent materials are relatively easy to operate and maintain. Many sorbent materials change colors when they need to be replaced; others use pop-up indicators that extrude through the grate when capacity is reached.

- These BMPs are passive structures with no moving parts, and thus they are not susceptible to mechanical failure or breakdown.

- Most synthetic sorbents retain their shape and will not break down under field conditions. Some sorbents are enclosed in polypropylene encasements to prevent damage from ultraviolet exposure. Others, such as the DrainGuard™ catch basin and curb opening systems, are held within a polypropylene "sock" that is supported by a rigid frame which ensures that the insert maintains its shape as storm water flows through it.

- These sorbents are designed to retain sorbed contaminants and minimize the potential for leaching. Most sorbents discussed in this Fact Sheet meet RCRA requirements prohibiting the release of sorbed liquids, making them acceptable at RCRA Subtitle D landfills.

Disadvantages

- Sorbent materials require frequent inspection to ensure that the sorbent material is not fully used or "spent". Each type of sorbent material has a maximum sorbent capacity based on its chemical composition and volume. When this capacity is reached, the sorbent will no longer capture oil and grease and must be replaced.

- Sorbent material can capture only the free oil and grease present in the water column. It cannot capture emulsified oils.

- A California Department of Transportation (CalTrans) study involving drain inlet inserts with sorbent materials found that units clogged frequently, causing flow bypass and ponding (Othmer, et. al., 2001). Large litter and debris, such as leaves, clogged the inserts, decreasing the system's hydraulics and reducing sorbing capability.

- Most local jurisdictions require proper disposal of used sorbent, either through landfilling or incineration. Proper handling and disposal of used sorbent material is discussed in more detail in the **Operation and Maintenance** section of this Fact Sheet.

MEDIA CHARACTERISTICS

Sorbents can be divided into three basic categories: natural organic, natural inorganic, and synthetic. Table 1 describes the three materials and their sorbent capacities. This Fact Sheet focuses on synthetic sorbents; however, many BMPs can be fitted with natural organic or inorganic sorbents to help absorb oil and grease.

PERFORMANCE

Stenstrom and Lau (1998) tested five different sorbents, including Rubberizer® and OARS® media, in a Continuous Deflection Separation (CDS) device for their ability to remove free oil and grease. A CDS device is an on-line hydrodynamic separator (see EPA Fact Sheet on Hydrodynamic Separators, EPA 832-F-99-017). The researchers floated sorbents on the surface of an unmodified CDS unit, introducing free oil at an approximate rate of 25 mg/L. This concentration is within the range of 10 to 35 mg/L which has been reported as the average storm water oil and grease concentration in urban runoff (U.S. EPA 1999a). The researchers measured concentrations of oil and grease in the effluent to determine removal efficiencies. Removal efficiencies for the different sorbents ranged from 41 to 87 percent at a flow rate of 8 L/s (125 gpm). All but one of the tested sorbents removed at least 77 percent of the oil and grease. The removal rates appeared to depend on the flow rate of the influent. OARS® sorbent material was tested at three flow rates, ranging from 5 to 12 L/s (75 to 190 gpm). This flow rate is within a range of 30 to 75 percent of the design flow of the CDS device used in the experiments. Analysis of the removal rates from these experiments showed that, in general, the lower the flow rate, the higher the removal rate. Table 2 summarizes the results.

The Rubberizer® and OARS® sorbents showed similar levels of performance in these tests. Both were denser than the influent, causing them to float just below the circulation pattern that allowed them to achieve high removal efficiencies for surface oil and some emulsified

TABLE 1 MEDIA CHARACTERISTICS

Type of Media[1]	Description	Sorbent Capacity
1. Organic	Leaf compost, peat moss, straw, hay, sawdust, ground corncobs, feathers, and other readily available carbon-based products.	3 to 15 times their weight in oil
2. Inorganic	Clay, perlite, vermiculite, glass wool, sand or volcanic ash.	4 to 20 times their weight in oil
3. Synthetic	Man-made materials similar to plastics, such as polyurethane, polyethylene, and nylon fibers.	Up 70 times their weight in oil
3a. Rubberizer®	Non-toxic, non-hazardous polymers	1 lb material adsorbs 1.9 to 2.5 L (0.5 to 0.67 gal) of oil
3b. OARS® Smart Sponge	Combination of petroleum derived co-polymers	2 - 14.5 times its weight in oil
3c. Imbiber Beads™	Solid, spherical plastic particles	Each bead absorbs up to 27 times its own vol.

[1] For more detailed information visit http://www.epa.gov/oilspill/sorbents.htm

Source: EPA, 2000; Abtech Industries, 2000; Haz-Mat Response Technologies, 2000; and IMTECH, 2000.

TABLE 2 OIL & GREASE REMOVAL IN A CDS UNIT USING SORBENT MEDIA

Sorbent Type	Flow (GPM)	Percent Removal of 25 mg/L Oil and Grease
Nanofiber	125	87
OARS®	75	94
OARS®	125	86
OARS®	190	82
Rubberizer®	125	86
Sponge Rok	125	41
Xsorb	125	79
No Sorbent	125	77

Source: Stenstrom and Lau, 1998.

oils.

The researchers also measured oil and grease effluent concentrations 30 minutes after oil and grease pumping was stopped to determine whether oils leached out of the sorbents. Effluent oil and grease concentrations were generally less than 1 mg/L for all trials, indicating that most sorbents retained oil and grease. The only sorbent with a residual oil and grease concentration greater than 1.0 mg/L was Rubberizer®, which had a 1.96 mg/L oil and grease concentration in the effluent 30 minutes after oil and grease pumping had been stopped. The researchers speculate that this increased leaching rate may be the result of Rubberizer's® high Q value, which is a measure of the ratio of the oil and grease absorbed per mass of sorbent (Stenstrom and Lau, 1998).

Few other studies have directly tested the oil sorption efficiencies of sorbent materials, but several studies do compare the efficiencies of different BMPs that use oil sorbent materials. While these studies do not provide specific comparisons of sorbent materials because of the confounding effects of the types of BMPs utilized, they do illustrate the effectiveness of different BMPs that use sorbent materials in storm water applications.

The Rouge River National Wet Weather Demonstration Project monitored four on-line media filter devices (Hydrocartridge®, alternately using Rubberizer® and Woolzorb® media; StreamGuard™, using Rubberizer® media; Gullywasher™, using cellulose media; and the grate inlet skimmer box, which also used cellulose media) for a 19 month period at two gas station sites in southeast Michigan. The study found that all four units removed some debris, sediment, and oil; however, the Hydrocartridge® retained almost twice the amount of oil as the next most effective device (Alsaigh, et. al., 1999, see Table 3). The authors concluded that the Hydrocartridge® and the StreamGuard™ devices absorbed more oils and grease than the skimmer box and the Gullywasher™, and pose two potential explanations for the observed differences:

- The Hydrocartridge® and StreamGuard™ may have been better able to retain water, thereby slowing the flow and allowing the media to absorb oil; or

- The absorbents used by the Hydrocartridge® and the StreamGuard™ were more effective at removing oils than the cellulose media used by the skimmer box and the Gullywasher™ .

The authors did not directly test these possibilities, and therefore they make no conclusions as to which of them caused the Hydrocartridge® and the StreamGuard™ devices to absorb more oils and grease than the skimmer box and the Gullywasher™ (Alsaigh, et. al., 1999).

TABLE 3 OIL ABSORPTION EFFICIENCIES OF FOUR STORM WATER BMPS UTILIZING SORBENT MATERIALS

Device	Average Oil Captured/Gallon Filtered ((mg/kg)/1,000 gal)
Hydrocartridge®	9,700
StreamGuard™	5,000
Gullywasher™	2,100
Grate Inlet Skimmer Box	700

Source: Alsaigh, et. al., 1999.

The results allow some comparison between Rubberizer®, a synthetic polymer, and Woolzorb®, a natural wool fiber product. Both of these sorbent materials were used in the Hydrocartridge® BMP over the course of this project - Rubberizer® during six observation periods and Woolzorb® during two observation periods. The efficiency of Rubberizer® media ranged from a low of 200 mg/kg of oil captured per 1,000 gallons of storm water filtered to a high of 46,700 mg/kg of oil captured per 1,000 gallons of storm water filtered. The efficiency range of the Woolzorb® media overlaps that of the Rubberizer® media. The Woolzorb® media absorbed 11,500 mg/kg oil per 1,000 gallons of storm water filtered during the first observation period, and 2,600 mg/kg oil per 1,000 gallons of storm water filtered during the second period observed (Alsaigh, et. al., 1999).

The California Department of Transportation conducted a comprehensive study to evaluate two drain inlet inserts for their suitability for retrofitting into existing highway infrastructure. As part of this study, CalTrans estimated the pollutant removal efficiencies of three Fossil Filter™ units containing Fossil Rock, an amorphous alumina silicate, and three DrainGuard™ units containing Rubberizer® media, installed at sites in District 7 (Los Angeles County) maintenance stations (Othmer Jr. et. al., 2001). These maintenance stations were ideal for testing the units' hydrocarbon removal capabilities because they are used for vehicle storage, fueling, and/or maintenance operations. One Fossil Filter™ and one StreamGuard™ unit were installed at each site to allow within-site comparisons. The units were monitored from September 1999 through May 2000, with routine maintenance conducted according to the manufacturer's recommended schedule to reduce the likelihood of clogging. When it became apparent that the systems clogged at a much higher than expected rate, maintenance schedules were increased. However, even the increased maintenance schedules did not prevent clogging during storms and resulting system bypass.

The authors concluded that both units reduced hydrocarbons in storm water, but that site-specific conditions, such as flow rates, dictated the effectiveness of the unit. The mass balances were calculated, then converted to percent removal values to determine hydrocarbon removal efficiencies. The authors noted that removal efficiencies may be low because bypass occurred frequently for both types of units. In addition, they note that the Fossil Filter™ unit often became clogged, further reducing removal efficiency. Hydrocarbon removal ranged from 5 to 7 percent for the Fossil Filter™ and from 2 to 31 percent for the StreamGuard™. StreamGuard™ achieved higher hydrocarbon removal efficiency at two of three sites studied. The authors also emphasize that the units' intensive maintenance requirements are a factor to be considered when determining which BMP is appropriate for a specific application.

OPERATION AND MAINTENANCE

The basic operations and maintenance (O&M) requirements for sorbent materials include periodic checks to ensure that they have not reached their sorbing capacity or become clogged. The frequency of visits and cleaning of sediment and debris from BMPs using sorbent materials depends on the type of BMP and the area in which it is located. In general, all BMPs using oil sorbent materials should be inspected at least monthly. If the material is placed in an area where it is susceptible to a high oil loading rate, the BMP should be inspected and serviced more frequently. BMPS should be checked immediately in the event of an oil spill.

Inspections depend on the individual unit and vary from monthly to quarterly. For example, the Ultra-Urban™ Filter should be serviced quarterly to remove accumulated sediment and debris and to check the sorbent. The manufacturer recommends that OARS® Passive Skimmer systems be inspected at least once a month to check the position of the skimmer and ensure that it remains on top of the water for maximum oil removal efficiency. The unit should be changed when the sorbent material has turned from its original light color to a dark color, indicating that it has reached its maximum oil sorbing capacity. This changeout schedule depends on the specific application. AbTech estimates that a skimmer installed in an oil/water separator lasts between two weeks and three months, while a skimmer installed in a hydrodynamic separator will last two months to one year. Changeout involves removing the skimmer and replacing it with a new unit.

Foss Environmental recommends monthly inspections of its StreamGuard™ catch basin insert until the operator becomes familiar with how often the system needs to be cleaned of grit and sediment. The filter pack should be visually inspected and sediment removed, if necessary. To maximize removal efficiency, the catch basin insert system should be emptied and cleaned when it has accumulated 30 cm (12 inches) of sediment.

Disposal/Recycling

A sorbent must be replaced once it is spent or has reached its maximum sorbing capacity. Most of the sorbents discussed in this Fact Sheet can be removed and replaced easily by the user once they are spent. Depending on the type of sorbent, there are four different options for disposal: recycle, waste-to-energy (WTE), cement kilns and landfills.

Recycling offers an alternative to disposing of used oil sorbent materials. For example, CRI Recycling Service, Inc., recycles many types of used sorbent using a patent pending technology that effectively removes contaminants from both inorganic absorbent materials, such as clay and diatomaceous earth, and most synthetic absorbent materials, such as mats, pads, socks, and rolls. These absorbent materials can be reused after processing, with little change in their overall appearance or absorptive capacity. CRI has had success recycling both generic and proprietary sorbents.

WTE facilities utilize spent products to produce electricity as an alternative energy source. Cement kilns also utilize used products as an alternative fuel to produce Portland cement. The last option for disposal is landfilling the material. Most of the spent media has passed the EPA Toxicity Characteristic Leachate Procedures and the Paint Filter Test, qualifying it for acceptance at RCRA Subtitle D Landfills (i.e., most municipal landfills).

COSTS

AbTech Industries markets several storm water BMPs that use the OARS® Smart Sponge technology, including the OARS® Passive Skimmer, the OARS® Ultra-Urban™ Filter curb opening insert, and the OARS® Ultra-Urban™ Filter catch basin insert. Skimmer prices range from $18-$72, and skimmers are usually replaced when their sorbent capacity has been reached. AbTech's curb opening inserts cost $250, while catch basin inserts cost between $400 and $600. These units are used until their sorbent capacity is reached, and then the entire unit is replaced. Under normal operating conditions, the entire recyclable filter units should be replaced at least every three years.

Foss Environmental StreamGuard™ catch basin inserts (using the sorbent filter pack consisting of Rubberizer® media) sell for $93 each, with multiple packs available at a reduced cost. These inserts can be installed by the user, minimizing installation costs.

Imbiber Beads® Absorbent Pillows, which can be used in several different types of storm water BMPs, are sold in 18-pillow packs for approximately $275.

REFERENCES

Other Related Fact Sheets

Catch Basin Cleaning
EPA 832-F-99-011
September 1999

Handling and Disposal of Residuals
EPA 832-F-99-015
September 1999

Hydrodynamic Separators
EPA 832-F-99-017
September 1999

Water Quality Inlets
EPA 832-F-99-029
September 1999

Other EPA Fact Sheets can be found at the following web address:

http://www.epa.gov/owm/mtb/mtbfact.htm

1. AbTech Industries, 2000. Literature provided by manufacturer.

2. Alsaigh, R., J. Boerma, A. Ploof, and L. Regenmorter, 1999. Rouge River National Wet Weather Demonstration Project, Nonpoint Work Plan No. URBSW5, Task No. 3, Evaluation of On-Line Media Filters in the Rouge River Watershed.

3. American Society of Testing and Materials, 1993. *Standard Methods of Testing Sorbent Performance of Absorbents.* F 716-82 (Reapproved 1993).

4. American Society of Testing and Materials, 1996. *Standard Guide for Containment by Emergency Response Personnel of Hazardous Materials Spills*. F 1127-88 (Reapproved 1996).

5. American Society of Testing and Materials, 1999. *Standard Test Method for Sorbent Performance of Adsorbents.* F 726-99 (Reapproved 1993).

6. Caltrans-CSUS-UCD Stormwater Unit (study conducted by California DOT), August 2000. Brian Currier, Caltrans-CSUS-UCD Stormwater Unit, personal communication with Parsons, Inc.

7. CDS Technology, Inc., 2000. Literature provided by manufacturer.

8. CRI Recycling Service Inc., 2000. Literature provided by manufacturer.

9. CRI Recycling Service Inc., 2000. John Summerfield, CRI Recycling Service, Inc., personal communication with Parsons, Inc.

10. Haz-Mat Response Technologies, Inc., 2000. Literature provided by manufacturer.

11. Haz-Mat Response Technologies, Inc., 2000. Shirley Washum, Haz-Mat Response Technologies, Inc., personal communication with Parsons Engineering Science, Inc.

12. Hoffman, E.J., J. Latimer, G. Mills, and J. Quinn, 1982. "Petroleum Hydrocarbons in Urban Runoff from a Commerical Land Use Area." *Journal of the Water Pollution Control Federation* 54, No. 11, pp. 1517-1525.

13. IMTECH 2000. Literature provided by manufacturer.

14. Katers, J.F., and J. Summerfield, 2000. "Oil Recovery from Absorbent Materials."

15. Othmer Jr., E.F, G. Friedman, J.S. Borroum, and B.K. Currier, 2001. "Performance Evaluation of Structural BMPs: Drain Inlet Inserts (Fossil Filter™ and StreamGuard™) and Oil Water Separator." Submitted to American Society of Civil Engineers annual conference.

16. Stenstrom, M.K., G. Silverman, and T. Bursztynsky, 1984. "Oil and Grease in Urban Stormwaters." Journal of Environmental Engineering 110, No. 1, pp. 58-72.

17. Stenstrom, M. K. and Sim-Lin Lau, 1998. *Oil and Grease Removal by Floating Sorbent in a CDS Device*. Los Angeles. Prepared for CDS Technologies.

18. Stenstrom, M.K., 2001. M.K. Stenstrom, personal communication with Parsons, Inc.

19. U.S. EPA, 1999a. "Evaluating Simple, Cost Effective Solutions for Reducing Storm Water and Urban Runoff Pollution: Santa Monica Bay Restoration Project." *Coastlines*, January/February 1999. Internet site at http://epa.gov/owow/estuaries/coastlines/janfeb99/center/insert.html, accessed August 2000.

20. U.S. EPA, 1999b. *Sorbents.* Internet site at http://epa.gov/oilspill/sorbents.htm, accessed July 2000.

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