Cost Comparison of Storm Water Filters & Remediation Techniques

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Introduction

Urban runoff has been reported as the second most frequent cause of surface water pollution in the United States. The United States Environmental Protection Agency has reported that 87 percent of the major water basins in the country are affected by non-point source pollutants (Walker, 1998). The problem concerning urban runoff includes non-point management practices so that the combination of a city's runoff doesn't create contamination in the nearby streams and rivers. There is considerable controversy about the technical appropriateness and the cost-effectiveness of requiring cities to control contaminants in urban storm water discharges to meet state water quality standards (Jones-Lee and Lee, 1994).

In 1987, Section 402(p) was added to the Clean Water Act to establish a framework for addressing storm water discharges under the National Pollutant Discharge Elimination System (NPDES) program. In California the Clean Water Enforcement and Pollution Prevention Act of 1999 states a new requirement authorizing Regional Water Quality Control Boards (RWQCB) and Publicly Owned Treatment Works to require NPDES permittees and industrial users (i.e., indirect dischargers) to prepare and implement pollution prevention plans (Hickox, 1999). Therefore, all 11,258 gas stations in the state of California should have pollution prevention plans involving the use of best management practices.

Storm water quality best management practices (BMPs) range from non-structural contaminant control programs, such as the control of illegal connections and illicit discharges, to structural controls such as detention basins, grassy swales, and treatment works similar to those used for domestic and industrial waste waters (Jones-Lee and Lee, 1994). Some examples of simple regulatory BMPs for fuel dispensing areas are the using of dry clean-up methods such as sweeping for removal of litter and debris and the use of rags and absorbents for leaks and spills. Also, fueling areas should never be washed down unless the wash water is collected and disposed of properly. Another simple BMP for gas stations is labeling drains to indicate whether they flow to an oil/water separator, directly to the sewer, or to a storm drain. Unfortunately, gas station BMPs are often dependent on educating the employees on the situation concerning more government regulated clean up, so the accumulation of pollutants in our waterways continues to grow due to a lack of employee education. Other BMPs such as oil/water separators and catch basin inserts/filters are still being studied for efficiency and should become more utilized as more research is done.

A company called Stormwater Compliance International manufactures many different styles of filter inserts used to extract different pollutants from runoff. In a third party test report, done by the Environmental Technical Services, it was stated that these media have the ability to remove substances such as various aromatics that occur in fuels (benzene, toluene, xylenes, etc.), as well as other volatile (VOC) compounds, from water, and in effect, sequester them away from the environment until they dissipate (Conrad, 1999). When dealing with retail gas stations, small, localized spills often occur and have growing affects on the environment. These can be corrected by the use of media filters.

Retail Gasoline Outlets (RGOs) contain a number of different pollutants in their runoff which need to be controlled. Petroleum products contain the aromatic hydrocarbons benzene, toluene, ethylbenzene, and xylenes, otherwise known as BTEX, alkanes, and polynuclear aromatic hydrocarbons (PAHs) that are some of the most common contaminants of soils, sediments, and waters (Pierzynski, 2000). Without sufficient regulations of BMPs, the surrounding areas contaminated will have to be remediated, and the more complicated the pollutant the more costly the remediation. Soils and water contaminated with organic substances often involve more than one compound. Therefore, more than one remediation method may be necessary to address all of the contamination (Pierzynski, 2000). In California there are over 600 sites that are contaminated with petroleum by-products (Kostecki, 1989).

This paper is designed to determine whether using hydro-clean filter devices in storm drains of RGOs throughout California is more cost effective in comparison to the cost of remediation techniques to control pollution. The comparison involves an evaluation of general soil and sediment remediation techniques used for contamination, and the cost related to the remediation technique per area. In contrast to the above evaluation, another assessment was done concerning a filtering product and the cost for installation and maintenance of this product for a time period of thirty years.

Methods

The catch basin filters chosen for this comparison are part of the BMP of Stormwater Compliance International's new product line. The filter cost table was derived from the company's storm water filtration equipment catalog. The prices range by size and filter design with an average price range in the middle of the market. This filter can be used as an example of a wide variety of BMP products available today to control storm water runoff. The recommended filter model for a RGO from Stormwater Compliance International was the standard efficiency (SE) model with the price range, by size, shown in table 1.

TABLE 1: FILTER COST ANALYSIS

Recommended gas station filter SE model	**Prices**
steel frame 24x12	$ 195.00
overflow tray 24x12	$ 200.00
transition flow 24x12	$ 200.00
1 media SE tower	$ 365.00
1 sediment chamber 5L	$ 275.00
optional overflow capacity	N/A
1 media tower lid	$ 20.00
Total filter price	$ 1,255.00
3 replacement media bags/year	$ 195.00
Smallest SE filter model	
steel frame 12x12	$ 180.00
overflow tray 12x12	$ 100.00
transition flow 12x12	N/A
1 media SE tower	$ 365.00
sediment chamber	N/A
optional overflow capacity	N/A
1 media tower lid	N/A
Total filter price	$ 645.00
3 replacement media bags/year	$ 195.00
Largest SE filter model	
steel frame 48x48	$ 405.00
overflow tray 48x48	$ 1,600.00
transition flow 48x48	$ 1,600.00
8 media SE towers	$ 2,920.00
8 Sediment chambers 5L	$ 2,200.00
optional overflow capacity	N/A
8 media tower lids	$ 160.00
Total filter price	$ 8,885.00
24 replacement media bags/year	$ 1,560.00

Least expensive filter available		
steel frame 12x12		$ 180.00
overflow tray 12x12		$ 100.00
transition flow 12x12	N/A	
1 media tower LE (low efficiency)		$ 260.00
sediment chamber	N/A	
optional overflow capacity	N/A	
media tower lid	N/A	
Total filter price		$ 540.00
3 replacement media bags/year		$ 165.00

Most expensive filter available		
steel frame 48x48		$ 405.00
overflow tray 48x48		$ 1,600.00
transition flow 48x48		$ 1,600.00
16 media UHE (ultra high efficiency) towers		$ 10,000.00
sediment chambers	N/A	
optional overflow capacity		$ 1,600.00
effluent sampling tray		$ 100.00
media tower lids	N/A	
Total filter price		$ 15,305.00
48 replacement media bags/year		$ 3,120.00

The remediation technique and cost table (Table 2) was taken from a book called *Petroleum Contaminated Soils*, by Paul Kostecki. This book gave a very general idea of the different costs and techniques often used today when dealing with contaminated soil and sediment. Soil remediation costs vary concerning contamination type and concentration. The higher the contamination concentration, the greater the cost to dispose of the contaminants. This is also the situation for pollutants, as they get more hazardous the cost of remediation increases exponentially with the quality of restoration desired (Lecomte, 1999).

TABLE 2: REMEDIATION COST ANALYSIS

Remedial Technologies	**Relative Costs**
In Situ	
Volatilization	Low
Biodegradation	Moderate
Leaching	Moderate
Vitrification	High
Passive	Low
Isolation/containment	Low/Moderate
Non-In Situ	
Land treatment	Moderate
Thermal treatment	High

Asphalt incorporation	Moderate
Solidification	Moderate
Groundwater treatment	Low/Moderate
Chemical extraction	High
Excavation and landfill	Moderate/High
Low	~$10/cubic yard
Moderate	$10-100/cubic yard
High	>$100/cubic yard

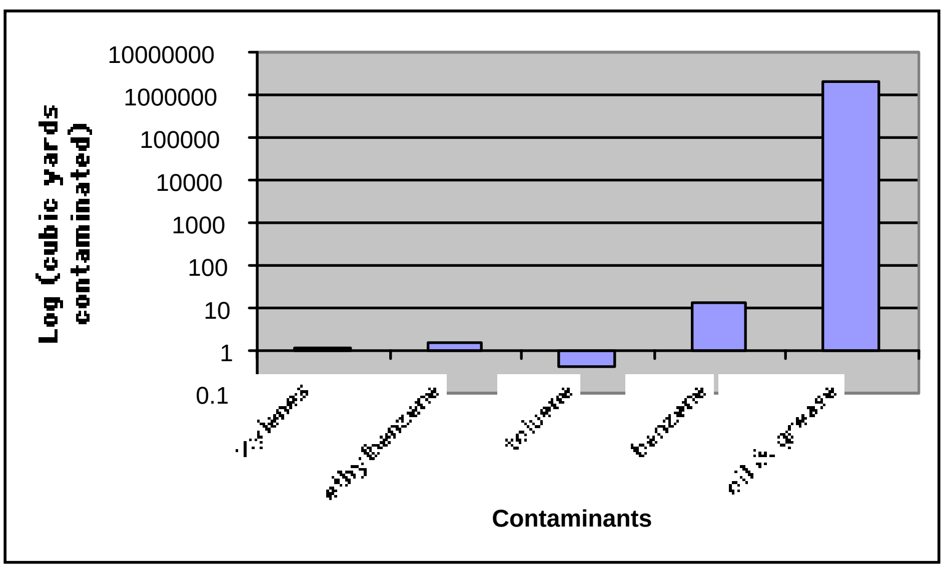
To figure out the amount of sediment contaminated from one year of storm water runoff from one RGO, several sources of data were used. One was involving the results of a storm water runoff study prepared by Geomatrix Consultants Incorporated for the data concerning the amount and kind of runoff pollution coming from different RGOs. This study is one of very few done to date. The average annual precipitation of Sacramento, California was used to represent the amount of annual precipitation throughout California. This data came from a United States Geological Survey web-site. To figure out the sediment criteria, data tables created by NOAA Squirt were used. The legal criteria standards were not available, so NOAAs reference tables were used as a substitute, yet these numbers can only give a general idea of the legal clean-up standards. Specific NOAA sediment criteria for the necessary organic pollutants were not given, so these numbers were derived from the maximum contaminant levels given for water, as seen in the example calculation (Table 3). This calculation was found by using the average pore space percentage for different types of soil/sediment, then multiplying that number by the maximum water contaminant limit, to give a sediment contamination limit. This was then used to calculate an estimation of how much possible sediment could be contaminated by the runoff of one RGO for a certain amount of rain per year. The pore space of different soil/sediment types was found by using the bulk unit weights of sand, silt, and clay from the *Handbook of Soil Mechanics*, in an equation for pore space. Soil criteria was also unavailable for the appropriate contaminants, so estimated contamination limits were taken from a study done by a San Francisco Bay Sediment Criteria Project.

The filters are built to last for thirty years. Thus taking the start-up cost and multiplying it by the total number of RGOs in California results in the startup cost for filters in California. Adding the cost per year on each filter, for thirty years of maintenance, created a total filter cost for a thirty-year period. Using numbers from a storm water runoff study done by Geomatrix at several gasoline outlets and water quality criteria combined with pore space data, the amount of potentially contaminated sediment and soil were collaborated. This data, multiplied by all of the gas stations in California, then multiplied by thirty years, gives an estimated conclusion concerning the amount of total pollution created by California gas stations over a thirty-year period. With the total amount of soil contaminated and the remediation cost range, a price for total remediation for this amount of soil was calculated. This number and the number calculated for the filter costs will show whether or not the use of filters would be more cost effective compared to remediation within a thirty year period. Since there was no soil criteria for oil and grease pollution, total petroleum hydrocarbons (TPHs) were used as another pollutant. In addition, there was no sediment criterion for TPHs when dealing with sediment, so oil and grease were used as a comparison.

Results

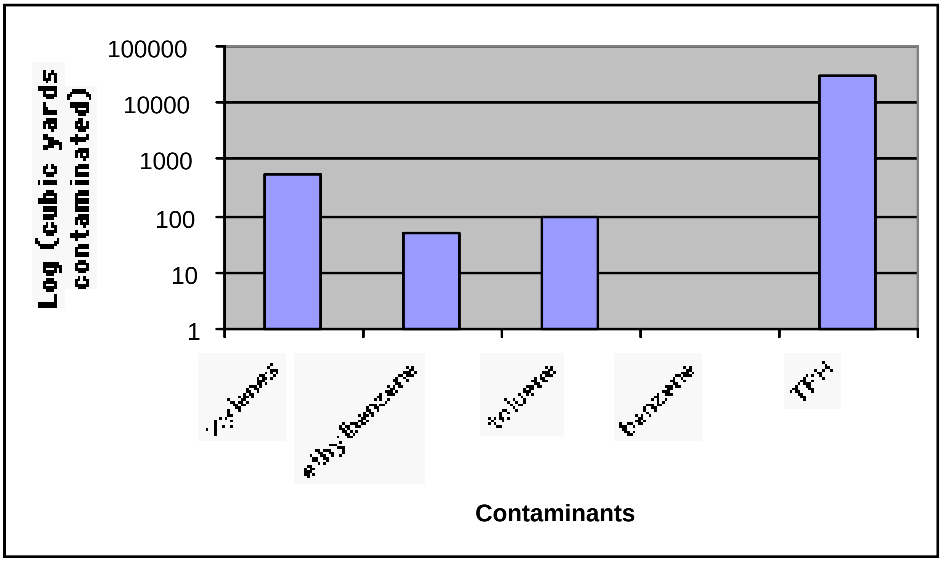
The calculated information has resulted in the conclusion that the petroleum products (xylene, ethylbenzene, toluene, and benzene) tested in the runoff have very low contamination rates in sediment ranging from 0.4 cubic yards per thirty years for all RGOs to 14 cubic yards shown in figure 1.

FIGURE 1: SEDIMENT CONTAMINATED FROM ALL RGOS IN CA/ THIRTY YRS



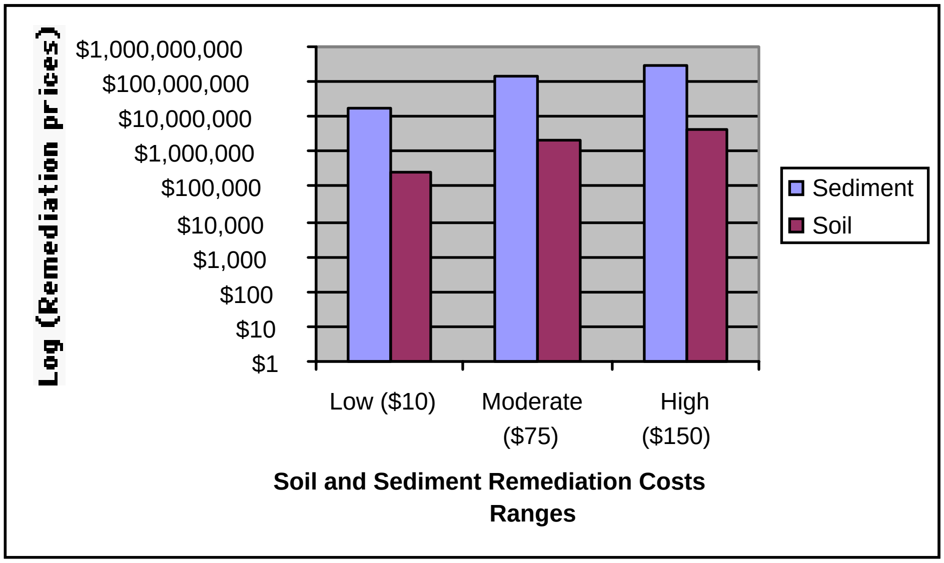
With soil contamination the petroleum products numbers range from 1 cubic yard to 550 cubic yards for all RGOs per thirty years as shown in figure 2.

FIGURE 2: SOIL CONTAMINATION FOR ALL RGOS IN CA/THIRTY YRS



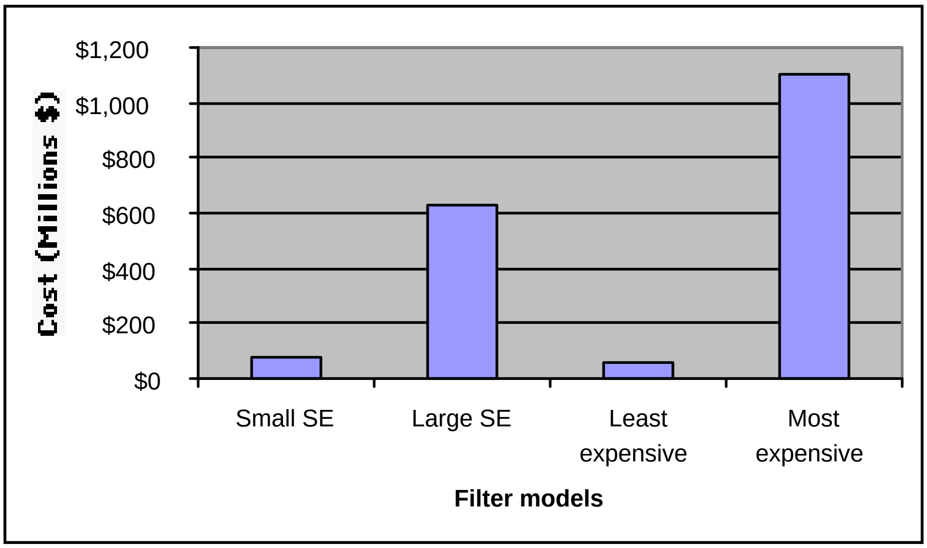
Oil and grease were found to be the main concern when dealing with runoff for sediment with a total affect of 2 million cubic yards for all RGOs in California for thirty years. For soil the main pollutant from RGOs was TPHs at 30 thousand cubic yards for thirty years. Even though the numbers were considerably lower when dealing with the individual parts of petroleum products, the total contaminants for soil and sediment for thirty years were used to find the overall total pollution from all of the RGOs in California. The total amount of sediment polluted was about 2 million cubic yards, and for soil it was about 30 thousand cubic yards. The thirty-year remediation costs, depending on technique used, ranged from a low of 18 million dollars to a high of 300 thousand dollars for sediment as shown in figure 3.

FIGURE 3: REMEDIATION COST RANGE FOR THIRTY YEARS



In comparison the costs of filter installations and maintenance in all of the 11,258 RGOs in California ranged from a low of 62 million dollars to a high of 1 billion dollars as shown in figure 4.

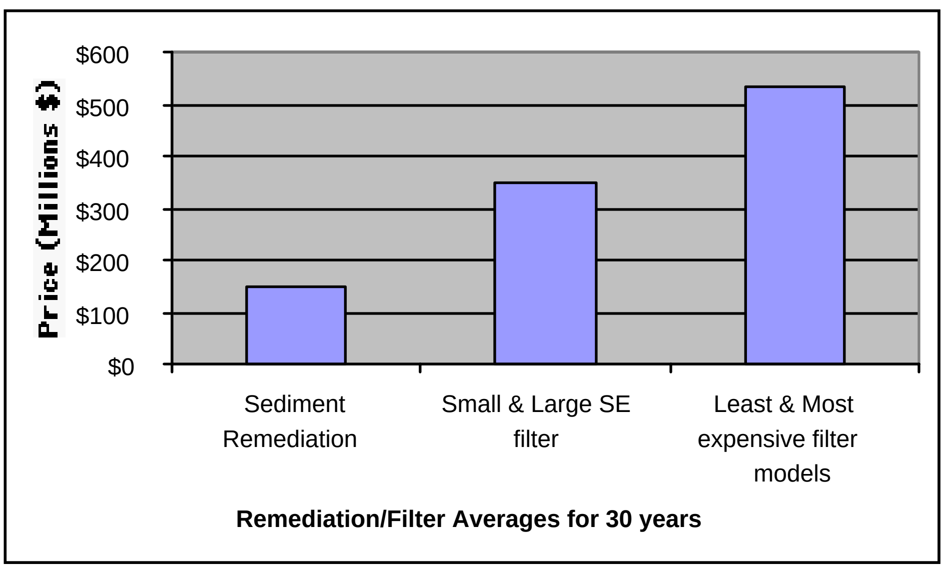
FIGURE 4: FILTER COSTS FOR THIRTY YEARS



Discussion

There are some circumstances which could lead to filter installations in California being less expensive than remedial costs for contaminated sediment and/or soil. If the state of California were to use either the small SE filter or the least expensive filter model available through Stormwater Compliance International Catalog, the cost over a period of thirty years would be cheaper than the moderate to high remediation costs for sediment. Depending on the size variation of the storm water drains, the large SE filter and the most technically efficient filter would be more expensive then the remedial costs for the RGOs pollution. Even using low cost remediation techniques and the low standard SE filter model, the filters would be more expensive. Realistically, remedial techniques vary and probably would stay in the moderate range of 10-100 dollars per cubic yard. If there were thirty years of mainly moderately priced remedial techniques used, then the small standard SE filter would be about 50 million dollars cheaper than pollution cleanup costs. There are several different circumstances that could cause the filter prices to be cheaper than remediation. For example, if the contamination concentration were extremely high in a site-specific area, then the filter prices would be cheaper then the remedial costs. However, the overall average estimation for the state of California shows that remedial costs are less expensive than filter costs, as shown in figure 5.

FIGURE 5: AVERAGE REMEDIATION AND FILTER COST COMPARISON



The comparison of soil versus sediment in this paper is another issue. When dealing with soil, the contamination is contained in a smaller area. When dealing with water runoff, the runoff ends up in another water body. Sediment is the soil submerged under a body of water. Therefore, because the pollutants spread out in the water before settling in the sediment there is a greater range of contamination. Evaluation of this pollution is determined by the location of the city in comparison to a surrounding water body. Because of this, there is a difference in contamination per cubic yard between soil and sediment criteria using different standards for calculating the total yardage. The NOAA screening table states that all tables were developed for internal use for screening purposes only: they do not represent official NOAA policy and do not constitute criteria or clean-up levels (NOAA Squirts, 1999). The table's conclusion was not only developed for screening purposes, but also to be informative of similar standards set for the country.

When comparing the prices involved in remedial techniques and alternative methods of environmental protection, there are other issues involved besides costs. The costs to the environment involved in allowing polluted storm water runoff to enter our waterways should be much more of a concern. Remediation is one way of cleaning up pollution in sediment, but remedial techniques alter the environment in some ways that can never be restored. There also is a cost to the public. How can you put a price on a public lake being closed due to pollution, or a beach that can't be used? In many ways the costs to the environment and to the public cannot be estimated. RGOs are only one type of business that adds to the storm water pollution problem. In some ways they may contribute more then other businesses, but there are ways for RGOs to protect themselves from harming the environment. BMPs are new ways of cleaning up runoff, but using filters would allow for humans to default. Once the filters were installed they would continuously do their job without being reminded, while forgetfulness is a human characteristic which can lead to the deterioration of our environment. Therefore, the filters can be considered to be better than any BMP. The costs may be an issue, but overall they could be saving the state money. The Geomatrix report proves that fueling activities at normally operated RGOs do not contribute additional significant concentrations of measured constituents in storm water runoff (Geomatrix, 1994).

In conclusion, BMPs may be a cheaper way for RGOs to protect their surrounding storm water, but filters would be a more cost-effective method for the government of California to reduce pollution. Simple BMPs like mopping are inconsistent in comparison to the efficiency and reliability of storm water filters.

TABLE 3: EXAMPLE CALCULATION

Sediment Contamination per Contaminant

1. Water Volume = (rain amount)(test area)
2. Concentration (contaminant) = given by averaging Geomatrix tests (ug/L)
3. Mass Loading/ RGO/ 20.5 inches rain/year =

   (concentration)(water volume)(RGO area/Geomatrix test area)
4. Pore Space = (wet soil weight - dry soil weight)/(dry soil weight)
5. Contaminant Criteria = (water criteria for contaminant)(pore space)
6. Sediment Contaminated (1 RGO/20.5 inches rain) =

   (mass loading)/(contamination criteria)
7. Sediment Contaminated for all RGOs in CA =

   (Sedment Contaminated 1 RGO)(All CA RGOs)

Remediation Costs

1. Add all sediment contamination numbers together from all contaminants
2. Remediation Costs = (Total Sediment Contamination (yd^3))(cost/yd^3)

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