Total Petroleum Hydrocarbons in Highway Maintenance Waste

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Highway maintenance wastes consisting of road sweepings, vactor sludges, and ditch spoil were contaminated by semivolatile and nonvolatile hydrocarbons. The total petroleum hydrocarbon (TPH) content in road sweepings ranged from 2 to 16 966 mg TPH/kg; that in vactor sludges and ditch spoils ranged from 251 to 7690 and 214 to 2541 mg TPH/kg, respectively. The TPH content of the fine particle-size fraction of the road sweeping was significantly higher than that present in the coarser fractions. Weathered road sweepings had a lower TPH concentration than did the fresh sweepings.

The disposal of road sweepings, vactor sludges, and ditch spoils from highway maintenance operations is coming under closer environmental scrutiny by federal, state, and local regulatory agencies. These wastes have long been recognized, in themselves, as being potentially hazardous materials or serving as surfaces onto which hazardous substances can sorb.

Because of increasing liability and monitoring costs, municipal landfills are reluctant to receive the materials because they may contain hazardous substances. Consequently, accumulation and storage of these materials occur at highway department maintenance sites at which they have become a disposal problem. As a result, highway departments are concerned with the proper management of these materials. Many states have established guidelines for disposal of waste materials. Many states have established guidelines for disposal of waste materials emphasizing the protection against contamination of surface and ground waters. Because there is little information about the contaminants within the waste materials, it is difficult to assess if the current waste management practices are effective.

The use of motor vehicles on roadways generates wastes containing hazardous heavy metals and organic compounds. Such heavy metals as lead, cadmium, and zinc are found, in a relatively immobile form, in road sweepings, vactor sludge, and in spoils from ditches adjacent to heavily traveled roads. These wastes contain a wide variety of organic compounds from the condensed gases and particulates from the internal combustion engine as well as oils and greases lost from the vehicles lubricating system.

The identity of specific organic compounds in the highway environment is only fragmentary. Because of the many sources of the contaminants, the types of compounds present cover a wide spectrum of hydrocarbons. Uncombusted gasoline contributes volatile hydrocarbons with low molecular weight such as short-chained alkanes and single-ring aromatics. Heavier semi- and nonvolatile hydrocarbons, such as long-chained straight and branched alkanes and polycyclic aromatics, are found in oil, greases, engine exhaust, asphalt deposits, and tire wear.

Early research of street sweepings is monitored by the Chemical Oxygen Demand (COD) and the Biochemical Oxygen Demand (BOD) (*1,2*). These studies focused on the impact of biodegradable organic contaminants on receiving waters.

Polycyclic aromatic hydrocarbons are a group of compounds that have been widely documented to be present in vehicle exhaust and street dust (*3–6*). These compounds are present in gasoline and oils and are also formed in combustion processes. Several members of the polycyclic aromatic hydrocarbon group are known carcinogens and are on the Environmental Protection Agency's (EPA's) Priority Pollutant and Washington State's Dangerous Waste lists (*7,8*).

The objective of this paper is to document information about the characterization and fate of organic contaminants, as measured by total petroleum hydrocarbons (TPHs), in wastes generated from highway maintenance operations.

RESEARCH PLAN

Site Selection

Samples were collected from waste piles at Washington State Department of Transportation (WSDOT) maintenance sites and along state highways. A map of the state of Washington, showing the sample site locations, is shown in Figure 1. Sample-site locations are indicated by filled circles. The number in parentheses following the sample-site name represents the number of waste piles sampled at that location. The numbers shown in large print (1 through 6) represent the six highway districts within WSDOT.

Samples were taken from three types of waste material: road sweepings, vactor sludges, and ditch spoils. Piles of varying ages were sampled to investigate the weathering effect on TPH concentrations. They ranged from samples of recently collected roadside piles to well-weathered piles at highway department maintenance sites. The waste piles ranged in size from a few to several thousand cubic yards. The type of waste material, origin of waste, and age of waste pile were among the data recorded.

Sample Collection

Samples were obtained by digging into the sides of waste piles at five or six locations and removing subsamples. Samples

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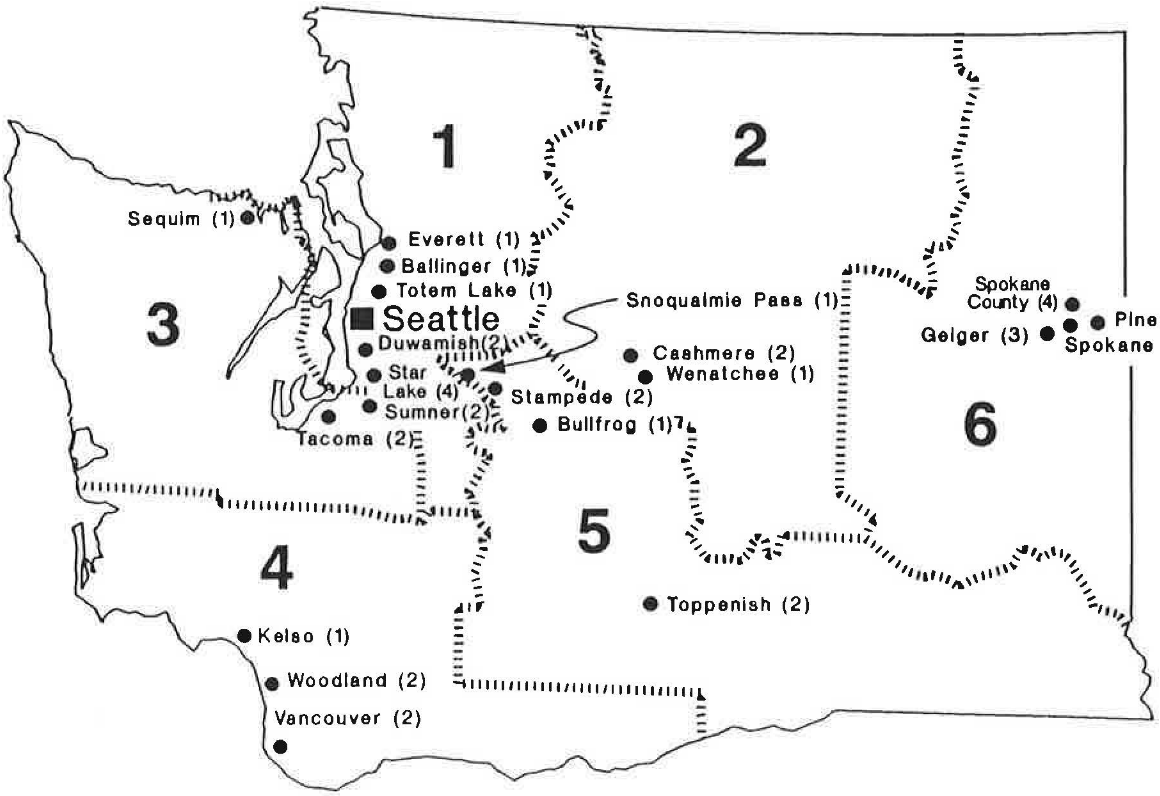

FIGURE 1 Sample-site locations.

were taken below the pile surface to a depth of about 2 ft. Subsamples were then mixed, and a composite sample was taken. The samples were placed in glass containers, iced, and transported back to the laboratory. Samples were then refrigerated at 4° C until extracted.

Total Petroleum Hydrocarbon

Since a wide range of organic compounds are present in highway maintenance wastes, a parameter was chosen that would measure a broad spectrum of compounds in a single analysis. The TPH analysis measures volatile, semivolatile, and nonvolatile hydrocarbon compounds, exception for the aromatic compounds present in the waste materials. The analysis does not identify specific hazardous substances in samples, but it is an effective screening method. Because there is no established method for measuring TPH in soils, a combination of Standard Method 5520E and EPA Method 418.1 was used (*9,10*). This procedure is valid for a TPH concentration range of 5 mg/kg to approximately 10,000 mg/kg (*11*). Several states use this procedure to analyzing petroleum-contaminated soils resulting from leaking underground storage tanks (*12*).

A Foxboro Co. MIRAN 1A CVF infrared analyzer was used in the analysis. The TPH parameter being a relative parameter is dependent upon the type of standard used. An EPA-recommended standard consisting of a mixture of n-hexadecane, isooctane, and chlorobenzene was used (*10*). Benzene, hexane, heptene, used motor oil, and lube oils were used as comparative standards. TPH concentrations given in this paper were based on the EPA standard.

Particle Size Distribution

An experiment was conducted to determine the particle size distribution of the waste materials and the concentration of TPH in the particle size fractions. The samples were air-dried and separated into three particle size fractions by mechanical sieving. The three particle sizes used in this study were as follows:

Particle Size	*Description*
> 2 mm	Coarse fraction consisting of gravel and large debris
< 2 mm > 250 μm	Medium fraction consisting mostly of small gravel, sand, silt, and vegetative matter
< 2 mm	Fine fraction consisting of loam and clays

Samples from each of the categories were analyzed for TPH.

RESULTS AND DISCUSSION

Sample Collection

A total of 39 composite samples were collected. The number of samples from each of the three waste categories is shown in Table 1.

Quality Control Analysis

Quality control analysis was performed using blanks, spiked blanks, spiked samples, and background samples to determine the accuracy and sensitivity of the analytical procedures.

TABLE 1 Summary of Samples by Waste Category

Type of Waste Pile	Number of Samples
Road sweepings	26
Vactor sludge	8
Ditch Spoils	5

Several samples were spiked with the EPA-recommended standard to further demonstrate the effectiveness of the extraction and analytical procedures. Table 2 shows the percentage recovery of the spiked samples. Low recovery was attributed in part to the heterogeneity of the sample and the difficulty in determining the "true" TPH concentration of the sample before spiking.

TPH Concentration of Waste Categories

Samples were analyzed in duplicate; selected samples were analyzed in greater replication. The results for each sample were averaged. Table 3 shows the range and mean values of TPH concentration for samples of each waste type. Both arithmetic and geometric means were determined. This analysis was conducted on a wet-weight basis, and moisture content was not accounted for. Wet-weight analysis was used because drying would result in the loss of volatile substances.

The results indicated that vactor sludges and road sweepings were higher in TPH than ditch spoils. It was apparent from the results that TPH concentrations of the waste materials vary greatly. Since a wide range of TPH concentrations was found in the waste materials, the geometric mean is a more accurate estimate of the average value.

Effects of Waste Pile Weathering on TPH Concentrations

During sample collection, information was obtained that allowed categorization by relative waste pile age. Waste pile age was determined using information obtained from local WSDOT personnel as well as by visual inspection of the waste piles. Although this was a qualitative method of estimating age, the sampled materials were separated into three road sweeping categories and two vactor sludge groups.

The freshest road sweepings were those that were found in recently swept small piles along the highway. These piles were typically less than a few weeks old. The second category of road sweepings were piles that had recently been deposited at highway maintenance sites. These piles, although generally older than the piles found along the highway, were not more than a few months old. The last category was for well-weathered road sweeping piles found at the highway maintenance sites. These piles were typically more than 6 months old.

The vactor sludges were classified as either wet (fresh) or dry (aged) waste piles. Wet sludges contained free water, and dry sludges had been allowed to drain and dry. Ditch spoils were not classified by age since only five samples were collected. Table 4 is a tabulation of the mean and range of concentration values for the weathered road sweeping categories and vactor sludges.

The results indicate that weathering of waste piles of road sweepings reduces the concentrations of TPH. These results were expected, because natural processes would reduce the concentration of contaminants over time. However, the effect of weathering was not obvious in vactor sludge samples.

Particle Size Analysis

Figure 2 shows the particle size distribution of typical samples from fresh sweepings and well weathered sweepings piles. The percentage of the fine fraction (<250 μm fraction) in the fresh road sweepings was found to be consistently higher than the weathered sweepings samples. This was attributed to the loss of fine fractions in the older piles by wind or runoff.

Figure 3 shows the concentrations of TPH in the three particle size fractions for the two samples indicated above. This analysis was conducted on a dry sample weight basis.

TABLE 2 Quality Control-Spike Sample Recovery

Spike Blank Number	Spike (mg TPH)	Sample TPH no spike (mg TPH/kg)	Sample TPH plus spike (mls)	% Recovery (of spike)
43	100	8082	12184	72
44	100	16966	21408	79
1	107	4157	8095	66
29	116	2467	7204	48

TABLE 3 TPH Concentrations in Waste Categories

Waste Type	TPH Concentration (mg (TPH/kg)		
	Arithmetic Mean	Geometric Mean	Range
Road sweepings	2524	1054	2-16966
Vactor sludge	2884	1788	251-7690
Ditch Spoils	954	664	214-2541

TABLE 4 Effect of Weathering on TPH Concentrations

Waste Type	Number of Samples	TPH Concentration (mg/kg) Arithmetic Mean	Geometric Mean	Range
Fresh roadside sweepings	5	3307	3215	2410-4157
Fresh sweepings at maintenance site	9	4560	2870	825-16966
Well weathered sweepings	12	671	312	2-2009
Wet vactor sludge	5	2503	1604	251-5787
Dry vactor sludge	3	1070	2412	553-7690

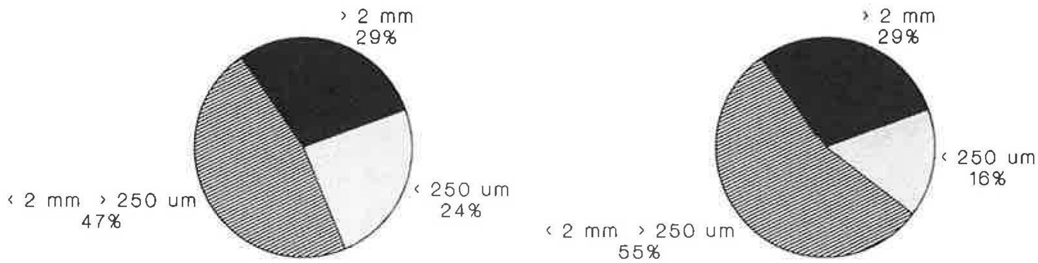

FIGURE 2 Particle size distribution, weight percent of particle size fractions: ***left*****, fresh roadside sweepings (Sample 29);** ***right*****, well-weathered sweepings (Sample 6).**

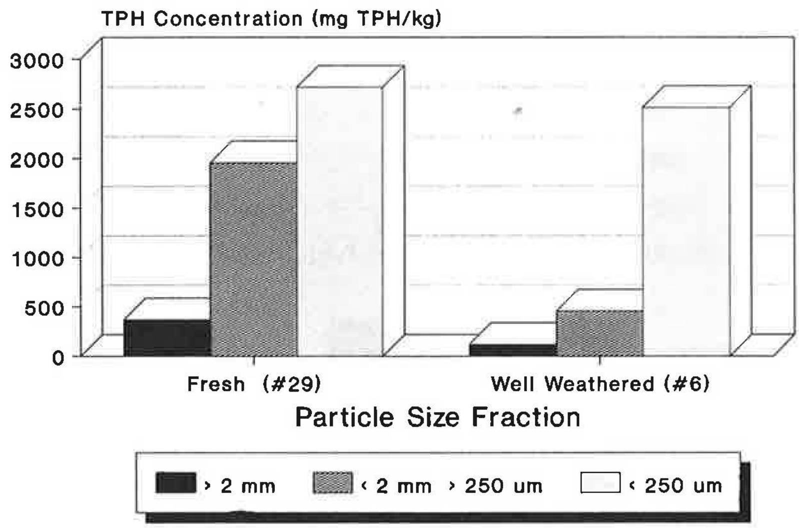

FIGURE 3 TPH concentration of particle size fractions.

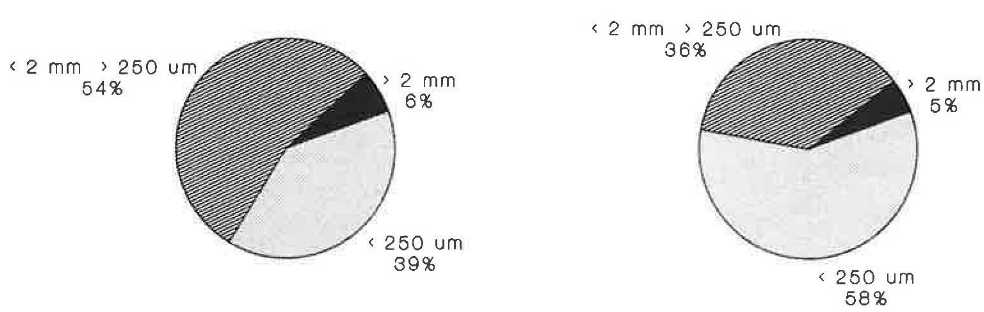

FIGURE 4 Percentage contribution of sample TPH concentration by particle size fractions: ***left*****, fresh roadside sweepings (Sample 20);** ***right*****, well-weathered sweepings (Sample 6).**

Figure 4 illustrates that TPH is more concentrated in the finer fractions. This is a common finding with contaminated soils. Sorption of organic compounds is highest by clay mineral particles that are included in the <250 μm fraction.

Figure 3 further emphasizes the importance of particle size on TPH concentration. In the two samples shown, the coarse fraction (>2 mm) makes up almost a third of the sample (by weight) and the TPH contribution is only 5 and 6 percent of the total sample.

SUMMARY AND CONCLUSIONS

This study has shown that highway maintenance wastes contained a wide concentration range of TPH. Road sweepings and vactor sludges generally were found to have higher concentrations of TPH than ditch spoils were.

Weathering of waste piles was found to reduce TPH concentration. Fresh piles of road sweepings along highways and at maintenance sites had much higher TPH concentrations than did well-weathered piles. Fresh road sweepings were found to have the highest concentrations of TPH compounds. Older waste piles were found to have lower concentrations. A correlation between waste pile weathering and reduction of TPH concentration was not found for the vactor sludge piles. The effect of weathering of ditch spoil piles was not determined.

TPHs were found to be concentrated in the smaller particle size fractions of the waste materials. The highest TPH concentrations were associated with the <250 μm fraction. The TPH concentration in the >2 mm fraction was generally found to be insignificant as compared to the total sample TPH.

ACKNOWLEDGMENT

The authors would like to acknowledge the assistance given by the maintenance staff at WSDOT district yards. The work reported herein is supported by a WSDOT grant agreement.

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Publication of this paper sponsored by Committee on Environmental Analysis in Transportation.