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Project Summary

A Method for Estimating Fugitive Particulate Emissions from Hazardous Waste Sites

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A literature review on fugitive particulate emissions from agricultural, industrial, and other activities was performed to identify control techniques which may be applicable to fugitive emissions from hazardous waste sites. Techniques judged applicable include chemical stabilization (40 to 100 percent efficiency, $520/acre-yr to $2,720/acre-yr), wet suppression (25 to 90 percent efficiency, $365/acre-yr to $1,270/acre-yr), physical covering (30 to 100 percent efficiency, $0.01/m² to $65/m²), vegetative covering (50 to 80 percent efficiency, $0.11/m² to $3.96/m²), and windscreens (30 to 80 percent efficiency, $18.01/m² to $26.90/m² of screen). Reducing vehicle speed on unpaved roads can reduce emissions by 25 to 80 percent depending on initial conditions.

Supporting reviews are included for soil characteristics, emission factors, and dispersion processes that generate and distribute fugitive particulate matter. A method is described to estimate degree of contamination (DOC) of soil particles based on the contamining chemical's water solubility and the soil's organic carbon content. A firt-order decay process is included. Five example sites are described and estimates made of uncontrolled and controlled downwind concentrations of hazardous constituents. Annual averages are in the attogram to nanogram per cubic meter range. Ranges for control and efficiency costs for each site are included.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Particulate emissions from hazardous waste sites may be significant contributors to offsite contamination. Liquid hazardous materials are adsorbed by surrounding soil particles that subsequently are windborne and inhaled by exposed populations or deposited on land or water used for food production. Similarly, solid materials may become eroded or windborne and eventually inhaled or deposited.

Examples of sites that can contribute to windborne contaminants include open waste piles, unpaved haul roads, landfills of various configurations, and dried lagoons. For each, some combination of mechanisms must allow a contaminating material to be adsorbed by containing or surrounding soil and dispersed in prevailing winds.

Methods of controlling fugitive particulate emissions range from preventing contaminants from reaching the soil or from being eroded (if solid) to planting vegetative covers that prevent soil movement. A site can be covered with benign material or crustal agents used to bond soil particles together to prevent soil movement. To determine the overall control effectiveness, one must be able to measure or estimate emission factors (controlled and uncontrolled) from sites of interest, degree of contamination (DOC) of emitted particles, and dispersion of particles.

A major objective of this report is to identify and evaluate individual control options for treatment, storage, and disposal facilities (TSDFs). A supporting objective is to provide data and estimation procedures to determine DOC of soils at TSDFs.

Procedure

Control techniques are described first, including their effectiveness and costs, followed by a brief discussion of soil characteristics important to estimating fugitive emissions. A method is described for predicting downwind concentrations of hazardous constituents and is applied to five example sites. Control efficiency and cost are given for each site.

Information for this report was taken primarily from the literature on agricultural, mining, and industrial emissions and from pesticides research. No field work was performed.

Results and Discussion

Control Techniques and Cost

Several control techniques for fugitive particulate emissions have been investigated and applied in recent years for sources such as storage and waste piles, paved and unpaved roads, cropland, construction areas, and in the handling and transfer of bulk solids. Very few of these techniques have been evaluated by field sampling at TSDFs; however they have been applied and evaluated at sources similar to TSDFs such that technology transfer should be straightforward. Evaluating these control techniques included investigating application methods and rates, practicality, and control efficiency.

Control efficiencies have been measured and reported in the literature in different ways by different investigators. The different methods of evaluating control efficiency include:

- Reduction in particulate matter in the ambient air
- Reduction in percent silt on the surface
- Reduction in soil movement
- Increase in wind threshold or entrainment velocity.

Control efficiencies are site-specific and depend upon a myriad of variables that change with the types of controls, emission sources, and climates. Even for a specific site, the control efficiency may vary day to day because of changes in the many variables affecting emissions. For these reasons, control efficiencies are presented in the form of ranges that are derived from the published results of several different investigators. Control methods reported in the literature include chemical stabilization, wet suppression, physical covering, vegetative covers, windscreens, and traffic speed reduction. A summary of the techniques, efficiencies, and costs is given in Table 1.

The practicality of these control options for specific sites depends upon active or inactive use, climate, and properties of specific products or controls. For example, vegetative covers are obviously impractical for the active portions of a site. Water-soluble chemical stabilizers may be impractical in areas with a high incidence of rainfall, and wet suppression techniques may be impractical in arid areas that have a limited water supply. The practicality of a given product or control technique for a specific site must be evaluated on a case-by-case basis and one should consider factors such as cost, desired control efficiency, expected lifetime of the control, climatic effects, and

Table 1. Summary of Control Costs and Efficiencies

Site and control technique	*Cost estimate ($/yr)*	*Total suspended particle (TSP) efficiency (%)*[a]	*Inhalable particle (IP) efficiency*[b]
40-acre landfill			
1. Chemical stabilization			
a. Partially active, frequent application	*35,500-109,000*	*75-100*	*Same*
b. Inactive, infrequent application	*3,700-9,200*	*75-100*	*Same*
2. Cover - inactive site			
a. Synthetic film, 5-yr life	*43,000-256,000*	*85-100*	*Same*
b. Hardened foam, 2 in., 5-yr life	*93,000*	*85-100*	*Same*
c. 6-in. soil cover, 5-yr life	*16,000*	*85-100*	*Same*
3. Vegetative stabilization, inactive site			
a. Hydraulic seeding, 10-yr life	*12,000*	*50-80*	*Lower*
b. Above plu topsoil	*26,000*	*50-80*	*Same*
c. Hydraulic seeding plus chemical stabilization	*15,700-21,200*	*85-100*	*Same*
4. Wet suppression			
a. For 1-acre active site	*365-1,270*	*25-90*	*Higher*
b. For entire 40 acres	*15,000-51,000*	*25-90*	*Higher*
Dried lagoon (1 acre)			
1. Chemical stabilization	*744*	*75-100*	*Same*
2. Cover			
a. Synthetic film, 5-yr life	*1,000-6,300*	*85-100*	*Same*
b. Hardened foam, 2 in., 5-yr life	*3,400*	*85-100*	*Same*
c. 6-in. soil cover, 5-yr life	*400*	*85-100*	*Same*
3. Vegetative stabilization			
a. Grade, seed, fertilize, 10-yr life	*1,100*	*50-80*	*Lower*
b. Hydraulic seed, fertilize, mulch, 10-yr life	*290*	*50-80*	*Lower*
c. Above plus local topsoil	*650*	*50-80*	*Same*

Table 1. *(Continued)*

Site and control technique	*Cost estimate ($/yr)*	*Total suspended particle (TSP) efficiency (%)[a]*	*Inhalable particle (IP) efficiency[b]*
4. Wet suppression			
a. Water spraying	*365-1,270*	*25-90*	*Higher*
b. With sprinkler system, 10-yr life	*1,500*	*25-90*	*Higher*
Drum storage area			
1. Chemical stabilization			
a. Yearly application	*151*	*75-100*	*Same*
b. Monthly application	*1,800*	*75-100*	*Same*
2. Cover			
a. Synthetic film, 5-yr life	*50-290*	*85-100*	*Same*
b. Dome cover, 10- to 20-yr life	*11,000-16,000*	*Up to 100*	*Same*
3. Vegetative stabilization			
a. Grade, seed, fertilize, 10-yr life	*52*	*50-80*	*Lower*
b. Above plus topsoil	*68*	*50-80*	*Same*
Unpaved road (0.5 mi)			
1. Chemical stabilization	*22,000-33,000*	*40-96*	*Same*
2. Cover			
a. 3 to 6 in. of gravel, 5-yr life	*5,000-9,200*	*30*	*Lower*
b. Pave, 3 in., 10- to 20-yr life	*6,500-8,500*	*85*	*Same*
c. Road carpet	*4,900*	*45*	*Same*
3. Wet suppression	*20,500-31,500*	*50*	*Higher*
Waste pile (1.8 acres)			
1. Chemical stabilization - active site	*1,600-4,900*	*75-90*	*Same*
2. Cover			
a. Synthetic film, inactive site, 5-yr life	*2,000-12,000*	*85-100*	*Same*
b. Above plus tension cables, auger feed, active	*52,000-79,000*	*85-100*	*Same*
c. Hardened foam cover, inactive site, 5-yr life	*5,300*	*85-100*	*Same*
3. Vegetative stabilization			
a. Grade, seed, fertilize, 10-yr life	*2,000*	*50-80*	*Lower*
b. Hydraulic seeding, mulch, 10-yr life	*540*	*50-80*	*Lower*
c. Above plus topsoil	*1,200*	*50-80*	*Same*
4. Windscreen, 10-yr life	*3,200-12,400*	*30-80*	*Lower*
5. Wet suppression	*660-2,600*	*25-90*	*Higher*

[a] Percent reduction in TSPs (total suspended particulate).
[b] Expected control of inhalable particles (IP) relative to TSP (higher, lower, or the same).

potential for creating other adverse environmental impacts (e.g., increased leachate generation or spread of contamination).

Estimation of Emissions

Estimating fugitive particulate emissions and resulting downwind ground-level contaminant concentration is a two-step process. The first step is to determine the emission or entrainment rate of particulates into ambient air, and the second step is to determine the atmospheric dispersion of the emitted material and resulting downwind concentrations. The theory of atmospheric dispersion and Gaussian diffusion models has been relatively well developed, and a number of computer models have been developed to predict downwind air and surface concentrations using point, line, or area sources of emissions. Estimating fugitive emissions from TSDFs, however, must be based on available data from other similar fugitive particulate emission sources such as unpaved roads, storage piles, and open-area sources.

Fugitive emissions from a hazardous waste facility or an open dust source may be expected to depend upon several factors:

- Soil characteristics such as particle size, organic content, moisture, soil type and texture, and erodibility. Soil properties determine the ease or propensity of particle entrainment.
- Climatic conditions such as mean wind velocity, humidity, and extent of precipitation and solar influx. These parameters affect the long-term average soil moisture content.
- Destabilizing factors such as mechanical activity and vehicle traffic on the site. Such factors may change

the soil surface characteristics and/or contribute mechanical energy for particle entrainment. Mechanical activity tends to restore a site's "erosion potential."

- Extent of nonerodible elements at a site determine its erosion potential. Elements such as clumps of grass or stones on the surface consume part of the shear stress of the wind that otherwise would be transferred to erodible soil.

Conclusions

Many fugitive particulate controls have been found that prevent or reduce contact between wind and soil particles. The most common type is some form of liquid, such as asphaltic compounds, that can be sprayed over soil surfaces to form crusts or to bond particles together. Other types include vegetative covers, wind breaks, and physical covers of soil, clay, or artificial materials. Control effectiveness depends on efficiency, longevity of actions, and resistance to wind and other erosive forces. A summary of control costs and efficiencies is given in Table 1. Calculations have been made for five emission sources to determine DOC, uncontrolled and controlled emissions, downwind concentration of hazardous materials, and control costs. Results from these calculations are presented in Tables 2 and 3. No data are available to check the validity of these projections. This information was developed from a broad review of control techniques discussed in hazardous waste, solid waste, mining, civil engineering, construction industry, and EPA documents.

Controls may be needed to prevent dispersion of hazardous waste emissions from areas of contamination. These emissions may be hazardous wastes in particle form but are more apt to be soil particles contaminated with the wastes. Few data have been found regarding degree of soil contamination at TSDFs; however, soil contamination by pesticides has been investigated extensively. Using the generalized results of these investigations, a method was developed for estimating DOC of soils from sparingly soluble hazardous waste. The method assumes that all contaminant retention on soil occurs by adsorption from a saturated solution and that all contaminant degradation (prior to particle emission) occurs from a first-order decay process. The only information required to use the method is water solubility for the compound of interest and organic carbon content of the adsorbing soil. If significant degradation of the contaminant is assumed, a value for the first-order rate constant is required, since results for two example TSDFs that could be checked are accurate to about 10 and 35 percent. Further work will be needed to establish the usefulness of this method.

Relatively little information has been found regarding site characteristics important for assessing downwind deposition from contaminated fugitive particulate matter. However, for prediction purposes, the several types of sites considered can be generalized to three models: line sources for contaminated roads; flat area sources for typical waste sites, landfills, and dried lagoons; and storage pile sources for waste piles.

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Table 2. *Emissions from Example Sites*

Source	Contaminant	DOC (µg/g)	Uncontrolled emission rate: TSP Dust	Uncontrolled emission rate: TSP Contaminant	Uncontrolled emission rate: IP Dust	Uncontrolled emission rate: IP Contaminant
1. Landfill	Toluene	3,640 (estimated)	1.07 g/s	3.9 mg/s	0.8 g/s	2.9 mg/s
2. Dried lagoon	Dieldrin	55.7 (estimated)	0.036 g/s	2.0 µg/s	0.022 g/s	1.23 µg/s
3. Drum storage	Dioxin (TCOD)	0.120 (measured) 0.078 (estimated with decay)	0.112 mg/s	13.4 pg/s	0.067 mg/s	8.06 pg/s
4. Haul road	PCB (Aroclor 1260)	125 (measured) 141 (estimated)	1,790 mg/s	224 µg/s	897 mg/s	119 µg/s
5. Waste pile	Pb and Zn	Pb 14,000 (measured)		16.2 mg/s		12.2 mg/s
		Zn 34,000 (measured		39.4 mg/s		29.6 mg/s
		combined)	1.16 g/s		0.87 g/s	

Table 2. *(continued)*

Source	Contaminant	DOC (µg/g)	Controlled emission rate: TSP Dust	Controlled emission rate: TSP Contaminant	Controlled emission rate: IP Dust	Controlled emission rate: IP Contaminant
1. Landfill	Toluene	3,640 (estimated)	0.16 g/s	0.59 mg/s	0.12 g/s	0.44 mg/s
2. Dried lagoon	Dieldrin	55.7 (estimated)	5.4 mg/s	0.30 µg/s	3.3 mg/s	0.185 µg/s
3. Drum storage	Dioxin (TCOD)	0.120 (measured) 0.078 (estimated with decay)	16.8 µg/s	2.01 pg/s	10.1 µg/s	1.21 pg/s
4. Haul road	PCB (Aroclor 1260)	125 (measured) 141 (estimated)	269 g/s	33.6 µg/s	135 mg/s	17.9 µg/s
5. Waste pile	Pb and Zn	Pb 14,000 (measured)		2.43 mg/s		1.83 mg/s
		Zn 34,000 (measured		5.91 mg/s		4.44 mg/s
		combined)	0.174 g/s		0.131 g/s	

Definitions: DOC - Degree Of Contamination
TSP - Total Suspended Particulate
IP - Inhalable Particulate

Table 3. *Controls for Example Sites*

Site	Control method	Efficiency Total	Efficiency Inhalable	Control cost Capital	Control cost Annualized ($/yr)	Method Chosen[a]
1. Landfill	Chemical stabilization	75-100	75-100	—	$ 3,700- 9,200	
	Vegetative plus chemical stabilization	85-100	85-100	72,000	$15,700-21,200	X
2. Dried lagoon	Chemical stabilization	75-100	75-100	—	$ 744	
	Synthetic film cover	85-100	85-100	4,000-24,000	$ 1,000-6,300	X
	Vegetative plus chemical stabilization	85-100	85-100	1,800-4,000	$ 1,030-1,400	
3. Drum storage	Chemical stabilization	75-100	75-100	—	$ 151-1,800	
	Synthetic film cover	85-100	85-100	190-1,100	$ 50-290	X
4. Haul road	Chemical stabilization	40-96	40-96	—	$22,000-33,000	
	Wet suppression	50	50	—	$20,500-31,500	
	Paving	85	85	54,000	$ 6,500-8,500	X
5. Waste pile	Chemical stabilization	75-100	75-100	—	$ 1,600-4,900	
		85-100	85-100	7,400-45,000	$ 2,000-12,000	X
		50-80	50-80	3,300-7,400	$ 540-2,000	
		30-80	30-80	3,200-12,400	$ 3,200-12,400	

[a] The lowest efficiency for each chosen method was used to calculate controlled emission rates shown in Table 2.

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The complete report, entitled "A Method for Estimating Fugitive Particulate Emissions from Hazardous Waste Sites," (Order No. PB 87-232 203/AS; Cost: $18.95, subject to change) will be available only from:

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