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Project Summary

Guidelines for the Use of Chemicals in Removing Hazardous Substance Discharges

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This project was undertaken to develop guidelines for the use of various chemical and biological agents to mitigate discharges of hazardous substances. Eight categories of mitigating agents are discussed along with their potential uses in removing hazardous substances discharged on land and in waterways. The agents are classified as follows: mass transfer media, absorbing agents, thickening and gelling agents, biological treatment agents, dispersing agents, precipitating agents, neutralizing agents, and oxidizing agents. Each of these classes is developed in terms of the agents' general properties, their use in spill scenarios, evnironmental effects, possible toxic side effects, and recommended uses.

A matrix of countermeasures has been developed that refers to various classes of mitigating agents recommended for treatment of hazardous substances involved in spills in or near a watercourse. The matrix includes a list of hazardous chemicals, the corresponding U.S. Environmental Protection Agency (EPA) toxicity classification, and the physical properties of the chemical.

This Project Summary was developed by EPA's Municipal Environmental 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

The 1972 Water Pollution Control Act Amendments gave the U.S. Environmental Protection Agency (EPA) responsibility for removing spilled hazardous substances from the environment. EPA was also made responsible for developing criteria to be used for designating substances as hazardous. Of the two criteria developed, the first involves the potential toxic effect of a substance on the biosphere. The second criterion considers the probability of spills based on annual production, methods of transporting, storage, physical-chemical properties, and past history. Based on these criteria, a proposed list of hazardous substances was published in the Federal Register (Vol. 40, No. 250) on December 30, 1975.

The responsibility EPA bears for hazardous material spills raises many questions about removing discharged hazardous substances effectively. Many parameters are involved in deciding how to counteract a hazardous substance spill, and which countermeasure (if any) to use. The guidelines developed by this study for mitigating hazardous material discharges are to be used by EPA in the future to expand and revise

Annex X of the National Oil and Hazardous Substance Pollution Contingency Plan, 40CFR1510, so that it includes specific reference to chemical use for spills of hazardous substances. The guidelines also establish a method for determining the circumstances under which a particular mitigating agent can be used and those under which the use of chemicals and other additives is harmful to the environment.

Results

Use and Effects of Mitigating Agents

Study results are outlined in Table 1, which summarizes the recommended uses for each class of agent and the possible toxic side effects associated with their use. The eight categories of mitigating agents are as follows: mass transfer media, absorbing agents, gelling and thickening agents, biological treatment agents, dispersing agents, precipitating agents, neutralizing agents, and oxidizing agents. The recommended uses, effectiveness, and possible toxic effects of these agents are discussed here briefly.

Note that the effectiveness of a mitigating agent depends largely on the specific spill situation. The amount of agent needed to counteract a hazardous substance discharge is dictated by many factors, including the size of the watercourse, the conditions of flow, and the possible long-term toxic effects of irretrievable contaminated agents and byproducts.

Mass Transfer Media—

Agents within this category include activated charcoal and ion exchange resins. Available evidence indicates that activated charcoal and ion exchange resins introduced in moderate amounts to the aquatic environment will not in themselves be toxic. But the desorption of a hazardous chemical from such mass transfer media in natural surface water and the potential persistence of these toxic organic compounds in the aquatic environment must be considered in any decision to use irretrievable mass transfer agents. We can safely assume that if those toxic compounds can be removed from the environment by biological processes, they can also be removed if bound to a mass transfer medium. We can also assume that the total toxic effect of those biodegradable materials can be reduced if mass transfer agents can be used to minimize acute toxicity.

Irretrievable mass transfer media should be considered acceptable for treating the class of materials that is biodegradable under all conditions.

Absorbing Agents—

The use of absorbing agents is generally limited to spills of oil and petroleum products. Natural agents such as straw, sawdust, etc., are routinely used in such cleanups. A variety of synthetic absorbents are available for mitigating both hydrophobic and hydrophilic chemicals. These absorbents are nontoxic and do not present a hazard to the environment in an uncontaminated state, but desorption of the spilled material from both natural and synthetic absorbents can be significant. For this reason, the use of absorbing agents is recommended only in those situations in which the sorbent can be removed from the environment.

Thickening and Gelling Agents—

Mitigating agents in this category are actually special types of absorbents used to immobilize the spilled material to prevent further spread into the environment and to condition the spill for mechanical removal. We recommend that these agents be used on land spills of all liquid materials on which they are effective. Certain agents should be considered appropriate for treatment of water spills of insoluble organics that float. Thickening or gelling agents should not be used on water spills of materials that sink or mix into the water column.

Biological Treatment Agents—

Biological agents have been shown to be effective in mitigating spills of oil and oil-derived products. Several limitations, however, exist to the use of these agents in the treatment of spilled organic materials.

Table 1. *Mitigation Summary*

Mitigation Category	*Possible Toxic Effect(s)*	*Recommended Uses*
Mass transfer media	*Desorption of hazardous substance - chronic toxicity.*	*Biodegradable substances.*
Absorbing agents	*Desorption of hazardous substance - chronic toxicity, increased biological oxygen demand.*	*All land spills. Insoluble organics that float, provided absorbent can be removed from the environment.*
Thickening and gelling agents	*No known toxic effects.*	*All land spills. Insoluble organics that float.*
Biological treatment	*Ecological imbalance. Toxicity of degradation products.*	*Biodegradable substances. Spills that are easily contained and monitored.*
Dispersing agents	*Increase in toxicity resulting from dispersed substances. Toxicity of degradation product of added agent.*	*Biodegradable substances.*
Precipitating agents	*Toxic effect of insoluble metal salts.*	*Removal of metal ions from solution.*
Neutralizing agents	*Toxicity resulting from change in pH from natural conditions. Toxic metal ion byproduct.*	*All spills involving acids or bases.*
Oxidizing agents	*Toxic intermediate reaction products. Oxidation of natural organic materials - ecological imbalance.*	*Limited to detoxification of hazardous substances in closed system to allow control of reaction.*

Considerable time is required by the biological degradation process, which makes it necessary to contain and isolate the spilled material from the environment before treatment. The bacterial culture must also be given sufficient nutrients and maintained in an environment that will encourage adequate growth. A culture maintenance program must therefore be initiated. Finally, no agent should be introduced into the environment if it will cause any significant change to the ecological balance of the treated waterway. Biological agents should be considered appropriate for treating spills of materials that are biodegradable, but only when conditions allow the contaminated environment to be contained for sufficient time to permit detoxification. Other types of mitigating agents should be used whenever possible.

Dispersing Agents—

Dispersing agents can be used to (1) increase the rate of biodegradation of spilled material, (2) protect aquatic fowl by removal of oil or other organics from surface water, (3) minimize fire hazards by dispersing hazardous material into the water column, and (4) prevent shoreline contamination. Some dispersants are toxic, however, and care must be exercised to prevent unnecessary harm to aquatic life.

Precipitating Agents—

Precipitation is a valid mitigating technique for removing toxic metal ions from solution. The technique generally requires the addition of either hydroxide or sulfide ions at elevated pH levels.

Hydroxide ions will re-enter the water column when the pH returns to neutral, creating the possibility of a long-term environmental hazard. Sulfide precipitation is thus recommended. At toxic concentrations of heavy metal ions, an insoluble metal sulfide will form and reduce toxicity rapidly. The precipitate is insoluble enough to reduce re-entry of metal ions into the environment to a nontoxic level. Further study will be necessary, however, to determine the long-term effect of metal salts on the water system.

A byproduct of sulfide precipitation is toxic hydrogen sulfide gas. To inhibit hydrogen sulfide formation, the sodium sulfide precipitating solution should be stabilized with sodium hydroxide.

Neutralizing Agents—

Neutralization is an acceptable method of treating all spills of acids and bases, provided some method for monitoring PH is available. Treatment should be accomplished on land whenever possible to prevent the spilled material from entering aquifers or surface water. Toxicity associated with pH change from normal values once the spill has entered a waterway is critical, in which case neutralization of the spill becomes the primary method of treatment.

Toxicity reduction is coupled with the return of normal pH values regardless of the neutralizing agent; however, care must be taken to select an agent that produces the least toxic byproducts. All other considerations being equal, weak acids and bases should be selected to neutralize a spill in preference to strong acids and bases. This policy will minimize the potential for overtreatment. The use of solid agents should also be avoided when possible.

Where the monitoring system is not accurate enough to ensure treatment to the exact pH desired, it is better to undertreat than to risk overtreatment. PH values between 6 and 9 are recommended.

Oxidizing Agents—

Oxidizing agents are toxic to most organisms at relatively low concentrations. The reactions are difficult to control and seldom go to completion, thus leaving toxic intermediate reaction products. The use of oxidizing agents should be limited to land or water spills that are completely contained. Furthermore, these agents should be used only as a last resort.

Countermeasure Matrix

A comprehensive list of the various types of mitigating agents and their potential uses has been generated in matrix format (Table 2). This countermeasure matrix refers to classes of agents recommended for treating hazardous substances involved in spills in or near waterways. The matrix is a comprehensive list of hazardous chemicals, the EPA toxicity classification for each, and the density and the physical form of the pure hazardous substance. Each chemical is also assigned a physical/ chemical/dispersal (P/C/D) factor, which has a range from 0.1 to 1.0 and is "....based on the solubility, density, volatility, and associated propensity for dispersal in water of each hazardous substance." 40CFR60002, December 30, 1975. The remainder of the matrix specifies which categories of countermeasures are effective for controlling hazardous substances discharged on the ground or in a waterway.

The full report was submitted in fulfillment of Contract No. 68-03-2093 by Claspan Corporation, Buffalo, NY, under the sponsorship of the U.S. Environmental Protection Agency.

Table 2. Hazardous Substance/Countermeasure Matrix

Material	EPA Category	Density	Physical Form	P/C/D Category	Mass Transfer Media			Neutralizing Agent		Precipitating Agent	Biological Treatment Agent	Gelling Agent	Absorbing Agent	Oxidizing Agent	Dispersing Agent
					Activated Carbon	Cationic Resin	Anionic Resin	Acid	Base						
Acetaldehyde	C	0.783	L	M	x				x			x	x		
Acetic acid	C	1.049	L	M	x				x		x	x	x		
Acetic anahydride	C	1.083	L	SF	x				x		x	x	x		x
Acetone cyanohydrin	C	0.90	L	SF	x							x	x		x
Acetyl bromide	D	1.52	L	SS	x		x					x	x		
Acetyl chloride	D	1.11	L	SS	x				x			x	x		
Acrolein	A	0.839	L	SF	x						x	x	x		x
Acrylonitrile	C	0.807	L	SF	x							x	x		x
Adiponitrile	D	0.95	L	SF	x							x	x		x
Aldrin	A	1.65	S	IS	x										
Allyl alcohol	B	0.854	L	M	x						x	x	x		
Allyl chloride	C	0.9	L	IVF	x						x	x	x		x
Aluminum fluoride	D	2.88	S	P	x	x	x			x					
Aluminum sulfate	D	1.69	S	P	x					x					
Ammonia	C	0.60	L	SF	x	x		x				x			x
Ammonium acetate	D	1.073	S	SM	x	x									
Ammonium benzoate	D	1.26	S	SS	x	x	x								
Ammonium bicarbonate	D	1.58	S	SS	x	x									
Ammonium bichromate	D	2.15	S	SS	x	x	x			x					
Ammonium bifluoride	D	1.21	S	SS	x	x	x			x					
Ammonium bisulfite	D	—	S	SS	x	x								x	
Ammonium bromide	D	2.43	S	SS	x	x	x								
Ammonium carbamate	D	—	S	SS	x	x	x								
Ammonium carbonate	S	—	S	SM	x	x									
Ammonium chloride	D	1.53	S	SS	x	x									
Ammonium chromate	D	1.91	S	SS	x	x	x								
Ammonium citrate	D	—	S	SS	x	x									
Ammonium fluoborate	D	1.85	S	SS	x	x	x								
Ammonium fluoride	D	1.31	S	SM	x	x	x			x					
Ammonium hydroxide	C	0.9	S/L	M	x	x		x				x			
Ammonium hypophosphite	D	—	S	SS	x	x									
Ammonium iodide	D	2.56	S	SM	x	x	x								
Ammonium nitrate	D	1.66	S	SM	x	x	x								
Ammonium oxalate	D	1.50	S	SS	x	x	x								
Ammonium pentaborate	D	—	S	SS	x	x	x								
Ammonium persulfate	D	1.98	S	SS	x	x									
Ammonium silicofluoride	C	2.01	S	SS	x	x	x								
Ammonium sulfamate	D	—	S	SM	x	x	x								
Ammonium sulfide	D	1.02	S	SS	x	x	x							x	
Ammonium sulfite	D	1.41	S	SS	x	x	x							x	
Ammonium tartrate	D	1.61	S	SS	x	x	x								
Ammonium thiocyanate	D	1.31	S	SM	x	x	x								
Ammonium thiosulfate	D	—	S	SM	x	x	x								
Amyl acetate	C	0.88	L	INF	x						x	x	x		x
Aniline	C	1.022	L	SS	x						x	x	x		x
Antimony pentachloride	C	2.34	S	P	x	x				x					
Antimony pentafluoride	C	2.99	S	P	x	x	x			x					
Antimony potassium tartrate	C	2.6	S	P	x	x	x			x					
Antimony tribromide	C	4.14	S	P	x	x	x			x					
Antimony trichloride	C	3.14	S	P	x	x				x					
Antimony trifluoride	C	4.38	S	P	x	x	x			x					

Table 2. *(continued)*

Material	EPA Category	Density	Physical Form	P/C/D Category	Mass Transfer Media			Neutralizing Agent		Precipitating Agent	Biological Treatment Agent	Gelling Agent	Absorbing Agent	Oxidizing Agent	Dispersing Agent
					Activated Carbon	Cationic Resin	Anionic Resin	Acid	Base						
Antimony trioxide	C	5.2	S	P	x	x				x					
Arsenic acid	C	2-2.5	S	P	x		x		x	x		x	x		
Arsenic disulfide	C	3.4	S	IS	x	x	x			x		x	x		
Arsenic pentoxide	B	4.09	S	P	x	x				x					
Arsenic trichloride	C	2.16	S	P	x	x				x					
Arsenic trioxide	B	3.89	S	P	x	x	x			x					
Arsenic trisulfide	B	3.43	S	IS	x	x	x			x					
Barium cyanide	A	—	S	SS	x	x	x			x				x	
Benzene	C	0.879	L	INF	x							x	x		x
Benzoic acid	D	1 266	S	SS	x				x			x	x		
Benzonitrile	C	1.01	L	SS	x							x	x		
Benzoyl chloride	D	1.20	L	SS	x							x	x		
Benzyl chloride	D	1.09	L	IS	x							x	x		
Beryllium chloride	D	1.90	S	P	x	x				x					
Beryllium fluoride	C	1.99	S	P	x	x	x			x					
Beryllium nitrate	C	1.56	S	P	x	x				x					
Butyl acetate	C	0.89	L	SF	x						x	x	x		x
Butylamine	C	0.74	L	M	x							x	x		
Butyric acid	D	1.00	L	M	x		x		x		x	x	x		x
Cadmium acetate	A	2.01	S	SS	x	x				x					
Cadmium bromide	A	5.19	S	P	x	x	x			x					
Cadmium chloride	A	4.05	S	P	x	x				x					
Calcium arsenate	C	3.0	S	IS	x		x			x					
Calcium arsenite	C	—	S	SS	x		x								
Calcium carbide	D	2.2	S	P	x										
Calcium chromate	D	2.89	S	SS	x		x								
Calcium cyanide	A	—	S	SS	x		x							x	
Calcium dodecylbenzene sulfonate	B	—	S	SS	x		x								
Calcium hydroxide	D	2.504	S	SS				x							
Calcium hypochlorite	A	2.35	S	SM	x				x						
Calcium oxide	D	3.40	S	SM	x										
Captan	A	1.5	S	SS	x								x		
Carbaryl	B	—	S	SS	x								x		
Carbon disulfide	C	1.26	L	SS	x							x	x		
Chlordane	A	1.59	L	IS	x							x	x		
Chlorine	A	3.2	L	SF	x								x		
Chlorobenzene	B	1.1	L	IS	x							x	x		
Chloroform	B	1.5	L/G	IS	x							x	x		
Chlorosulfonic acid	C	1.8	L	SS	x		x		x			x	x		
Chromic acetate	D	—	S	SS	x	x				x					
Chromic acid	D	2.7	L	SM	x	x			x	x		x	x		
Chromic sulfate	D	1.7	S	SS	x	x				x					
Chromous chloride	D	2.87	S	IS	x	x				x					
Chromyl chloride	D	1.91	S	SS	x	x				x					
Cobaltous bromide	C	2.47	S	P	x	x	x			x					
Cobaltous fluoride	C	4.46	S	P	x	x	x			x					
Cobaltous formate	C	2.13	S	P	x	x				x					
Cobaltous sulfamate	C	—	S	P	x	x				x					
Coumaphos	A	—	S	SS	x								x		
Cresol	B	1.0	S	SS	x						x	x	x		x
Cupric acetate	B	1.9	S	P	x	x				x					
Cupric acetoarsenite	B	—	S	IS	x	x	x			x					
Cupric chloride	B	3.39	S	P	x	x				x					
Cupric formate	B	1.83	S	P	x	x				x					
Cupric glycinate	B	—	S	P	x	x				x					
Cupric lactate	B	—	S	P	x	x				x					
Cupric nitrate	B	2.32	S	P	x	x				x					
Cupric oxalate	B	—	S	IS	x	x	x			x					

Table 2. *(continued)*

Material	EPA Category	Density	Physical Form	P/C/D Category	Mass Transfer Media: Activated Carbon	Mass Transfer Media: Cationic Resin	Mass Transfer Media: Anionic Resin	Neutralizing Agent: Acid	Neutralizing Agent: Base	Precipitating Agent	Biological Treatment Agent	Gelling Agent	Absorbing Agent	Oxidizing Agent	Dispersing Agent
Cupric subacetate	B	1.9	S	P	x	x				x					
Cupric sulfate	B	2.28	S	P	x	x				x					
Cupric sulfate ammoniated	B	—	S	P	x	x				x					
Cupric tartrate	B	—	S	IS	x	x				x					
Cuprous bromide	B	4.72	S	IS	x	x	x			x					
Cyanogen chloride	A	1.186	G	SS	x	x									
Cyclohexane	C	0.779	L	INF	x						x	x	x		x
2,4-D acid	B	0.82	—	IS									x		
2,4-D esters	B	—	—	IS									x		
Calapon	B	1.38	L	SS	x							x	x		
DDT	A	—	S	IS	x							x	x		
Diazinon	A	1.116	L	IS	x							x	x		
Dicamba	C	—	S	SS	x								x		
Dichlobenil	C	—	S	SS	x								x		
Dichlone	A	—	S	SS	x							x	x		
Dichlorvous	A	—	L	SS	x								x		
Dieldrin	A	1 75	S	SS	x								x		
Diethylamine	C	0 71	L	SF	x						x	x	x		x
Dimethylamine	C	0.68	L	SF	x						x	x	x		x
Dinitrobenzene	C	1.54	L	SS	x						x	x	x		x
Dinitrophenol	B	1.68	L	SS	x						x	x	x		x
Diquat	C	—	S	SS	x								x		
Disulfoton	A	1 14	L	SS	x								x		
Diuron	B	—	S	SS								x	x		
Dodecylbenzene-sulfonic acid	B	—	L	SS	x		x				x	x	x		x
Dursban	B	—	—	SS	x								x		
Endosulfan	A	—	S	SS	x								x		
Endrin	A	—	S	IS	x								x		
Ethion	A	1.22	L	SS	x							x	x		
Ethylbenzene	C	0 958	L	INF	x						x	x	x		x
Ethylenediamine	C	0 96	L	SF	x						x	x	x		x
EDTA	D	—	S	IS	x						x		x		x
Ferric ammonium citrate	C	—	S	P	x	x	x			x					
Ferric ammonium oxalate	C	—	S	P	x	x				x					
Ferric chloride	C	2.89	S	P	x	x				x					
Ferric fluoride	C	3.52	S	P	x	x	x			x					
Ferric nitrate	C	1.68	S	P	x	x				x					
Ferric sulfate	C	2.0	S	P	x	x				x					
Ferrous ammonium sulfate	C	1.87	S	P	x	x	x			x					
Ferrous chloride	C	1.93	S	P	x	x				x					
Ferrous sulfate	C	1.899	S	P	x	x				x					
Formaldehyde	C	0.815	L	M	x		x				x	x	x		x
Formic acid	C	1.22	L	M	x				x		x	x	x		x
Fumaric acid	D	1 635	L	SS	x				x		x	x	x		x
Furfural	C	1 15	L	SS	x						x	x	x		x
Guthion	A	1.44	L	IS	x							x	x		
Heptachlor	A	1.58	S	IS	x								x		
Hydrochloric acid	D	1.00	L	SS	x		x		x			x	x		
Hydrofluoric acid	D	1.15	L	M	x		x		x			x	x		
Hydrogen cyanide	A	0.70	L/G	M	x		x		x			x	x	x	
Hydroxylamine	D	1.23	S	SS	x								x		
Isoprene	C	0.681	L	IVF	x						x	x	x		x
Isopropanol-amine dodecyl-benzenesulfonate	B	0.90	L	SS	x						x	x	x		x
Kelthane	C	—	—	IS	x								x		
Lead acetate	D	2.25	S	P	x	x	x			x					
Lead arsenate	D	7 8	S	IS	x	x	x			x					
Lead chloride	D	5.85	S	P	x	x				x					
Lead fluborate	D	—	S	P	x	x	x			x					
Lead fluoride	C	8 2	S	IS	x	x	x			x					
Lead iodide	D	6 16	S	IS	x	x	x			x					
Lead nitrate	D	4.53	S	P	x	x	x			x					
Lead sterate	D	1 4	S	P	x	x				x					
Lead sulfate	D	6 2	S	IS	x	x				x					
Lead sulfide	C	7 1	S	IS	x	x	x			x				x	
Lead tetra-acetate	D	2.23	S	P	x	x				x					
Lead thiocyanate	D	3.8	S	IS	x	x				x					
Lead thiosulfate	D	5.18	S	IS	x	x				x					
Lead tungstate	D	8.24	S	IS	x	x	x			x					
Lindane	A	1.87	S	SS	x								x		

Table 2. *(continued)*

Material	EPA Category	Density	Physical Form	P/C/D Category	Mass Transfer Media: Activated Carbon	Mass Transfer Media: Cationic Resin	Mass Transfer Media: Anionic Resin	Neutralizing Agent: Acid	Neutralizing Agent: Base	Precipitating Agent	Biological Treatment Agent	Gelling Agent	Absorbing Agent	Oxidizing Agent	Dispersing Agent
Lithium bichromate	D	2.34	S	SM	x	x	x			x					
Lithium chromate	D	—	S	SM	x	x	x			x					
Malathion	A	1.23	L	SS								x	x		
Maleic acid	D	1.59	S	SS	x				x		x		x		x
Maleic anhydride	D	0.934	S	SF	x				x		x		x		x
Mercuric acetate	A	3.25	S	P	x	x				x			x		
Mercuric cyanide	A	4.09	S	P	x	x	x			x			x	x	
Mercuric nitrate	A	4.3	S	P	x	x				x			x		
Mercuric sulfate	A	6.47	S	P	x	x				x			x		
Mercuric thiocyanate	A	—	S	IS	x	x	x			x			x		
Mercurous nitrate	A	4.79	S	P	x	x				x			x		
Methoxychlor	A	1.41	S	IS	x								x		
Methyl mercaptan	B	0.87	L/G	INF	x							x	x		x
Methyl methacrylate	D	0.936	L	INF	x							x	x		x
Methyl parathion	B	1.358	L	IS	x							x	x		
Mevinphos	A	—	L	M	x							x	x		
Monoethylamine	C	1.01	—	M	x								x		x
Monomethylamine	C	—	—	SF	x								x		x
Naled	A	—	S/L	IS	x							x	x		
Naphthalene	B	1.162	S	IS	x								x		
Naphthenic acid	A	1.4	S	SS	x							x	x		
Nickel ammonium sulfate	D	1.92	S	P	x	x				x					
Nickel chloride	D	3.55	S	P	x	x				x					
Nickel formate	C	2.15	S	P	x	x				x					
Nickel hydroxide	C	4.36	S	IS	x	x				x					
Nickel nitrate	D	2.05	S	P	x	x				x					
Nickel sulfate	D	1.948	S	P	x	x				x					
Nitric acid	C	1.502	L	M	x				x			x			
Nitrobenzene	D	1.19	L	SS	x							x	x		
Nitrogen dioxide	C	1.448	L/G	M	x										
Nitrophenol	B	1.4	L	SS	x						x	x	x		x
Paraformaldehyde	C	1.46	S	SS	x						x		x		x
Parathion	A	1.26	L	IS	x							x	x		
Pentachlorophenol	A	1.978	S	IS	x							x	x	x	
Phenol	B	1.071	S	SS	x		x				x	x	x		
Phosgene	D	1.392	G/L	SS	x								x		x
Phosphoric acid	D	1.834	L	M	x				x			x	x		
Phosphorus	A	1.8-2.7	S	IS											
Phosphorous oxychloride	D	1.67	L	SS	x	x						x			
Phosphorous pentasulfide	C	2.03	S	SS	x										
Phosphorous trichloride	D	1.574	S	SS	x	x	x								
Polychlorinated biphenyls	A	—	S	IS									x		
Potassium arsenate	C	2.87	S	P	x		x								
Potassium arsenite	C	—	S	P	x		x								
Potassium bichromate	D	2.68	S	SS	x		x								
Potassium chromate	D	2.73	S	SS	x		x								
Potassium cyanide	A	1.52	S	SS	x		x							x	
Potassium hydroxide	C	2.04	S	SM	x			x							
Potassium permanganate	B	2.7	S	SS	x		x								
Proprionic acid	D	0.993	L	M	x				x		x	x	x		x
Proprionic anhydride	D	1.013	L	M	x				x		x	x	x		x
Propyl alcohol	D	0.8	L	M	x						x	x	x		x
Pyrethrins	C	—	L	SS								x	x		
Quinoline	A	1.09	L	SS	x							x	x		x
Resorcinol	B	1.27	S	SS	x						x		x		
Selenium oxide	C	3.954	S	SS	x	x				x					
Sodium	C	0.971	S	SS											
Sodium arsenate	C	1.76	S	SS	x		x								
Sodium arsenite	C	1.87	S	SS	x		x								
Sodium bichromate	D	2.52	S	SM	x	x									
Sodium bifluoride	D	2.08	S	SS	x		x			x					
Sodium bisulfite	D	1.48	S	SS	x		x							x	
Sodium chromate	D	1.483	S	SS	x		x								
Sodium cyanide	A	1.48	S	SS	x		x							x	
Sodium dodecylbenzene sulfonate	B	—	S	SS	x		x				x		x		x
Sodium fluoride	D	2.78	S	SS	x		x			x					
Sodium hydrosulfide	D	—	S	SS	x		x						x		
Sodium hydroxide	C	2.13	L	SS	x			x				x			

Table 2. *(continued)*

Material	EPA Category	Density	Physical Form	P/C/D Category	Mass Transfer Media			Neutralizing Agent		Precipitating Agent	Biological Treatment Agent	Gelling Agent	Absorbing Agent	Oxidizing Agent	Dispersing Agent
					Activated Carbon	Cationic Resin	Anionic Resin	Acid	Base						
Sodium hypochlorite	A	—	S	SM	x		x								
Sodium methylate	C	2.4	S	SS	x		x				x		x		x
Sodium nitrite	B	2.17	S	SS	x										
Sodium phosphate monobasic	D	2.04	S	SS	x										
Sodium phosphate dibasic	D	2.06	S	SM	x										
Sodium phosphate tribasic	D	1.5	S	SS											
Sodium selenite	C	1.63	S	SS			x								
Sodium sulfide	C	1.856	S	SS	x		x			x				x	
Stannous fluoride	D	2.79	S	SS		x	x			x					
Strontium chromate	D	—	S	IS	x	x	x			x					
Strychnine	C	1.36	S	SS	x								x		
Styrene	C	0.909	L	INF	x							x	x		x
Sulfuric acid	C	1.834	L	M	x				x			x	x		
Sulfur monochloride	D	1.69	S	SS	x				x						
2,3,5-T acid	A	—	S	IS									x		
2,4,5-T esters	A	—	S	IS									x		
TDE	A	—	S	IS	x								x		
Tetraethyl lead	A	1 659	L	IS	x							x	x		
Tetraethyl pyrophosphate	B	1.2	L	M	x							x			
Toulene	C	0.86	L	INF	x						x	x	x		x
Toxaphene	A	1.66	L	IS	x							x	x		
Trichlorfon	B	1.73	S	SS	x								x		
Trichlorophenol	A	1.1	L	IS	x							x	x		
Triethanolamine dodecylbenzene sulfonate	B	—	L	SS	x							x	x		
Triethylamine	C	1.13	L	SF	x						x	x	x		x
Trimethylamine	C	0.66	L	SF	x						x	x	x		x
Uranium peroxide	D	2.5	S	IS	x	x				x					
Uranyl acetate	D	2.89	S	P	x	x				x					
Uranyl nitrate	D	2.80	S	P	x	x				x					
Uranyl sulfate	D	3.28	S	P	x	x				x					
Vanadium pentoxide	C	3.36	S	P	x	x				x					
Vanadyl sulfate	C	—	S	P	x	x				x					
Vinyl acetate	C	0.94	S	SF	x						x	x	x		x
Xylene	C	0.86	L	INF	x							x	x		x
Xylenol	C	1.02	L	SS	x							x	x		
Zectran	C	—	—	SS	x								x		
Zinc acetate	C	1.735	S	P	x	x				x					
Zinc ammonium chloride	C	1.80	S	P	x	x	x			x					
Zinc bichromate	C	—	S	P	x	x	x			x					
Zinc borate	C	3.64	S	P	x	x	x			x					
Zinc bromide	C	4.22	S	P	x	x	x			x					
Zinc carbonate	C	4.42	S	IS	x	x				x					
Zinc chloride	C	2.907	S	P	x	x				x					
Zinc cyanide	A	1.85	S	IS	x	x	x			x				x	
Zinc fluoride	C	4.84	S	P	x	x	x			x					
Zinc formate	C	2.21	S	P	x	x				x					
Zinc hydrosulfite	C	—	S	P	x	x	x			x				x	
Zinc nitrate	C	2.07	S	P	x	x				x					
Zinc phenolsulfonate	C	—	S	P	x	x	x			x					
Zinc phosphide	C	4.55	S	IS	x	x	x			x					
Zinc potassium chromate	C	—	S	IS	x	x	x			x					
Zinc silicofluoride	C	2.1	S	P	x	x	x			x					
Zinc sulfate	C	3.54	S	P	x	x				x					
Zinc sulfate monohydrate	C	3.28	S	P	x	x				x					
Zirconium acetate	D	—	S	P	x	x				x					
Zirconium nitrate	D	—	S	P	x	x				x					
Zirconium oxychloride	D	—	S	P	x	x				x					
Zirconium potassium fluoride	D	—	S	P	x	x				x					
Zirconium sulfate	D	3.22	S	P	x	x				x					
Zirconium tetrachloride	D	2.8	S	P	x	x				x					

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The complete report, entitled "Guidelines for the Use of Chemicals in Removing Hazardous Substance Discharges," (Order No. PB 82-107 483; Cost: $9.50, subject to change) will be available only from:
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