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# Non-Hazardous Waste Generation

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## ABSTRACT

Of the 12 billion tons of waste generated annually in the United States; less than 10% is defined as hazardous under the provisions of RCRA. This paper summarizes the data available on some of the wastes that are defined as non-hazardous. These wastes include industrial non-hazardous waste, and several types of wastes that are currently exempted from hazardous waste regulations, such as oil and gas waste, mining wastes and other categories.

## INTRODUCTION

Most data on industrial wastes, such as the National Hazardous Waste Survey (1) and the RCRA Biennial Survey (2), focus on hazardous waste generation and management. While these data are extremely valuable, it is important to note that industrial hazardous waste represents less than 10% of the total waste generated in the United States. Wastes that are regulated under RCRA Subtitle D, including industrial non-hazardous waste, municipal waste, infectious waste, agricultural waste, mining waste, oil and gas waste, and other waste categories fall outside the scope of hazardous waste databases. The goal of this paper is to provide a brief overview of the nature and magnitude of the non-hazardous waste generated in the United States, focusing on industrial non-hazardous waste. This task is difficult because surveys on different types of non-hazardous waste have been conducted independently of one another and at different times. Therefore, data on non-hazardous waste generation are less plentiful, less consistent and less accessible than data on hazardous waste generation. No single database is available that includes data on generation and management of all types of non-hazardous waste. The main source of information for this paper is the Environmental Protection Agency's 1985 Report to Congress on Solid Waste Disposal in the United States (3,4).

## GENERATION AND MANAGEMENT OF NON-HAZARDOUS WASTE

In the 1984 Hazardous and Solid Waste Amendments (HSWA) to RCRA, EPA was required to assess the adequacy of existing Subtitle D criteria for preventing groundwater contamination. In response to this requirement, EPA assembled information on State programs, facilities, wastes and contamination impacts. Information was obtained from EPA files, from the States and

Table I. Non-Hazardous (RCRA Subtitle D) Waste Generation (3)

| Waste Category | Estimated Annual Generation Rate (million tons) | Year Data Collected |
|---|---|---|
| Industrial Nonhazardous Waste | 7,600[a] | 1985 |
| Oil and Gas Waste[b] | | |
| drilling waste | 129-871[c] | 1985 |
| produced waters | 1,966-2,738[d] | 1985 |
| Mining Waste[b] | >1,400 | 1983 |
| Municipal Solid Waste | 158 | 1986 |
| Household Hazardous Waste | 0.002-0.56 | 1986 |
| Municipal Waste Combustion Ash | 3.2-8.1 | 1988 |
| Utility Waste[b] | | |
| ash | 69 | 1984 |
| flue gas desulfurization waste | 16 | 1984 |
| Construction and Demolition Waste | 31.5 | 1970 |
| Municipal Sludge | | |
| wastewater treatment | 6.9 | 1986 |
| water treatment | 3.5 | 1986 |
| Very-Small-Quantity Generators[e] | | |
| hazardous waste (<100 kg/mo) | 0.2 | 1985 |
| Waste Tires | 240 million tires | 1983 |
| Infectious Waste | 2.1[f] | 1985 |
| Agricultural Waste | ≤ 1 billion gallons/day | |
| Approximate Total[g] | >11,387 | |

[a]Not including industrial waste that is recycled or disposed of off-site. Off-site values are not known.
[b]See reference 7.
[c]Converted to tons from barrels: 42 gals = 1 barrel, ~17 lbs/gal.
[d]Converted to tons from barrels: 42 gals = 1 barrel, ~8 lbs/gal.
[e]Small quantity generators (100-1,000 kg/mo waste) have been regulated under RCRA, Subtitle C, since October 1986. Before then, approximately 830,000 tons of small-quantity generator hazardous wastes were disposed of in Subtitle D facilities every year.
[f]Includes only infectious hospital waste and does not include infectious waste generated by doctors' offices, nusing homes, etc.
[g]Totals for some wastes such as waste tires are not included.

unpublished literature, and from other sources. The results of this study were submitted as the Report to Congress on Solid Waste Disposal (3,4). The main categories of non-hazardous waste, as defined in that report, are listed in Table I. Estimated rates of waste generation are also listed in the Table. Industrial non-hazardous waste clearly dominates the list, accounting for more than 70% of all non-hazardous waste generation.

Management practices for each of the different types of Subtitle D wastes vary. For example, municipal solid wastes may be disposed of on land (83%) or they can be incinerated (6%) or materials can be recovered (11%). Infectious wastes usually require some treatment (to render the waste noninfectious) before they are placed in disposal facilities. Industrial non-hazardous wastes which are the major Subtitle D wastes (~70%), are mainly disposed of in landfills, surface impoundments, or waste piles.

Additional information on industrial non-hazardous waste can be obtained from two sources. These sources are: Industrial Facilities Survey, conducted by the Office of Solid Waste (5); and the Summary of Data on Industrial Nonhazardous Waste Disposal Practices (7). The first study is a survey of 17 major industries. Using the results of this survey, Table II reports the generation and management of industrial non-hazardous waste by industry sector. According to these data, the pulp and paper industry and the primary iron and steel industry generate almost half of all industrial non-hazardous waste. These data contrast with the information available on *hazardous* waste generation, which show the chemical products industry and, to a lesser extent, the petroleum refining industry as the primary generators (1,6). The accuracy of the data presented in Table II is difficult to assess. One approach to verification is to compare the data to the other non-hazardous waste survey. The study of industrial non-hazardous waste disposal, collected by SAIC for the EPA (7), presents data on 22 major industries (encompassing all but one of the 17 industries surveyed by the Office of Solid Waste) and includes a review of available data on industrial non-hazardous waste characteristics and generation rates. Table III summarizes some of the information reported in this study (4,7). On initial examination, there appear to be discrepancies between the two sources of data, particularly for the pulp and paper, electric power generation, and the primary iron and steel industries. The EPA recommends use of the data in Table II. To examine this apparent discrepancy and to further verify the waste data, we will briefly examine raw material usage and product manufacturing rates for various industry sectors.

Table II. Industrial Non-Hazardous Waste On-Site Management (1985)

| Industry Type (Standard Industrial Classification Code) | Total Waste Quantity Disposed of in All On-Site Industrial Facilities (thousand tons) | Percent of Waste Disposed of in Landfills[a] | Percent of Waste Disposed of in Surface Impoundments | Percent of Waste Disposed of in Land Application Units | Percent of Waste Disposed of in Waste Piles |
|---|---|---|---|---|---|
| Organic Chemicals (2819) | 58,864 | 0.4 | 96.3 | 3.1 | 0.08 |
| Primary Iron and Steel (3312-3321) | 1,300,541 | 0.3 | 99.2 | <0.01 | 0.5 |
| Fertilizer and Agricultural Chemicals (2873-2879) | 165,623 | 3.5 | 93.1 | 0.5 | 2.9 |
| Electric Power Generation (4911) | 1,092,277 | 4.9 | 95.0 | 0.03 | 0.08 |
| Plastics and Resins Manufacturing (2821) | 180,510 | 0.05 | 98.2 | 0.02 | 1.7 |
| Inorganic Chemicals (2812-2819) | 919,725 | 0.4 | 95.1 | 0.01 | 4.5 |
| Stone, Clay, Glass and Concrete (32) | 621,974 | 1.2 | 97.3 | <0.01 | 1.5 |
| Pulp and Paper (26) | 2,251,700 | 0.3 | 99.3 | 0.4 | 0.07 |
| Primary Nonferrous Metals (3330-3399) | 67,070 | 2.1 | 84.3 | 0.6 | 13 |
| Food and Kindred Products (20) | 373,517 | 1.0 | 78.6 | 20 | 0.1 |
| Water Treatment (4941) | 58,846 | 0.3 | 84.5 | 15 | 0.1 |
| Petroleum Refining (29) | 168,632 | 0.2 | 99.6 | 0.2 | 0.05 |
| Rubber and Miscellaneous Plastic Products (30) | 24,198 | 2.2 | 97.4 | 0.2 | 0.2 |
| Transportation Equipment (37) | 12,669 | 1.4 | 93.1 | <0.01 | 4.6 |
| Textile Manufacturing (22) | 253,780 | 0.03 | 99.7 | 0.3 | <0.01 |
| Leather and Leather Products (31) | 3,234 | 0.3 | 99.4 | 0 | 0.3 |
| Selected Chemicals and Allied Products | 67,987 | 0.2 | 99.1 | 0.7 | 0.01 |
| TOTAL | 7,616,149 | 1.1 | 96.6 | 1.3 | 1.0 |

SOURCE: References 4 and 5

[a]Percentages (in each row) are rounded and may not total 100 percent.

Table III. Non-hazardous Waste Generation from 22 Largest Quantity Generator Industries (7)

| Industry (Standard Industrial Classification Code) | Amount of Waste Generated (thousand dry tons/yr) | Year Data Collected |
|---|---|---|
| Organic chemicals (2819) | 1,072.4[a,b] | |
| Primary iron and steel (3312-3321) | 66,841.8[a] | 1983 |
| Fertilizer and other agricultural chemicals (2873-2879) | 65,033.5 | |
| Electric power generation (4911) | 61,553.0[a] | 1983 |
| Plastics and resins manufacturing (2821) | 49,600.0[a,b] | 1982 |
| Inorganic chemicals (2812-2819) | 28,852.0[a] | 1979 |
| Stone, clay, glass and concrete (32) | >20,489.1[c] | |
| Pulp and paper industry (26) | 9,503.2 | 1977 |
| Primary nonferrous metals (3330-3399) | 7,242.8[d] | |
| Food and kindred products (20) | 7,007.6[e] | 1976 |
| Water treatment (4941) | 5,463.8 | |
| Petroleum refining (29) | 1,406.0 | 1981 |
| Rubber and miscellaneous plastic products (30) | 597.7[a] | 1975 |
| Transportation equipment (37) | 572.8 | 1980 |
| Textile manufacturing (22) | >49.6 | |
| Leather and leather products (31) | 27.1[f] | 1975 |
| Electrical machinery and electronic components (36) | 11.5[g] | 1975 |
| Fabricated metal products (34) | 330.0[f,h] | 1983 |
| Lumber and wood products and furniture and fixtures (24 and 25) | >135.4[i] | |
| Machinery except electrical (35) | 213.2[j] | 1977 |
| Pharmaceutical (2831-2834) | 283.0 | 1973 |
| Soaps; other detergents; polishing, cleaning and sanitation goods (2841-2842) | 34.5[a] | 1981 |
| Approximate Total[k] | 362,320 | |

a. Dry or wet weight not specified; assume wet weight.
b. Estimated from the Industry Studies Database, compiled for the USEPA by SAIC.
c. This estimate is known to exclude significant quantities of nonhazardous wastes.
d. The waste streams in this category are numerous.
e. Wet weight.
f. Includes hazardous and nonhazardous wastes, depending on the source.
g. Data on waste types and amounts were available only for SIC 367 (represents only 2 percent of total value of 1976 product shipments for the industry).
h. Data on nonhazardous waste streams in this industry are almost completely nonexistent. The list of waste types is incomplete.
i. The total amount of wastes within this industry is large; however, most of the wastes are recycled; no quantities on total waste generation are available.
j. Includes only wastes from SIC 355 and 357 (representing 12 percent of total sales in SIC 35).
k. Total is approximate because of the limitations such as those of footnotes a,c,f-h.

Consider, as a first example, the pulp and paper industry. According to industry production data, approximately 80 million tons paper and paperboard were produced domestically in 1988 (8). This figure is in reasonable agreement with the estimated mass of paper and paperboard in the municipal solid waste stream. Based on these production figures, there can be only one explanation for the waste generation rate for the pulp and paper industry listed in Table II (over one billion tons per year). That explanation is that the dominant waste stream is dilute wastewaters. This presumption is consistent with the fact that a single large pulp mill will use 30-40 million gallons of water per day (roughly 50 million tons/year) (9). Twenty to thirty large paper mills could account for the waste mass estimated in Table II. Thus, it is conceivable that both Table II and Table III are correct estimates of waste generation for the pulp and paper

industry, and the differences in reporting are due mainly to the differences in wet and dry waste weights. There are other limitations in data collection, but they are applicable to both studies and do not result in such significant differences. Similar analyses and conclusions can be performed for electric power generation, where wet scrubbing wastes are significant, and iron and steel making, where extensive pickling wastewaters are generated.

Consider next the chemical manufacturing industry. Production of the top 50 commodity chemicals totals over 300 million tons per year (10). Converting these production estimates into estimates of waste generation requires yield data, where yield is defined as the mass of product divided by the mass of raw materials used. Analysis of industry average yield data is complex, as we will demonstrate using the example of chlorobenzene manufacturing via the chlorination of benzene. According to industry average data (11), producing one ton of chlorobenzene requires 0.77 ton benzene and 0.79 ton chlorine. Byproducts of the chlorobenzene synthesis are dichlorobenzene and hydrogen chloride. Dichlorobenzene is formed at a rate of 0.11 tons per ton of chlorobenzene and hydrogen chloride is formed at a rate of 0.40 ton per ton of chlorobenzene (11). A simple mass balance on these average yield data show that for 1.56 tons of material fed to the process, 1.51 tons of products are generated. Thus up to 0.05 tons of waste may be formed per ton of chlorobenzene produced. This estimate is certainly an upper bound since some minor products such as trichlorobenzene may be recovered as useful products. It is not, however, an unreasonable estimate for the amount of waste from the process of chlorinating benzene. For the industry as a whole, waste from chemical manufacturing is a few percent of production when viewed on a dry mass basis. This estimate is based on data from the Chemical Manufacturers' Association (12) and the EPA (1) which indicate that the Chemical Processing Industry generates over 200 million tons of wastewater annually and over 6 million tons of solid waste, compared to over 300 million tons of production. A yield analysis of the entire chemical manufacturing industry is beyond the scope of this paper, but may be possible with existing data.

The simple analyses described above, for the chemical manufacturing industry and the pulp and paper industry, reveal interesting features of the data on non-hazardous waste generation. First, the examples show that waste volume or waste mass measured on a dry weight basis can be very different from total waste. As shown in Tables II and III, rankings of industrial waste generators can be very different depending on whether the measurement basis is dry or total weight. In addition the analyses reveal that production data can lend new insights into waste generation, particularly when data are apparently inconsistent or confusing.

## CONCLUSION

Data on the generation of non-hazardous waste in the United States have been collected sporadically. As a result, the data are difficult to synthesize into an accurate picture of non-hazardous waste generation. Data taken during different time periods, using different methodologies and collected for different reasons must be integrated to perform a comprehensive analysis. Based on the data available, it is possible to conclude that nonhazardous wastes are dominated by industrial wastes primarily from mining, drilling, steel making, electric power generation, and paper products manufacturing. A comparison of total waste mass and dry waste mass from steel making, electric power generation and paper products manufacturing indicates that most of the waste mass from these industries is in the form of dilute wastewater.

## REFERENCES


1. Baker, R. D. and Warren, J. L., Hazardous Waste and Hazardous Materials (this issue).

2. 1987 National Biennial Report of Hazardous Waste Treatment, Storage, and Disposal

Facilities Regulated Under RCRA. Office of Solid Waste, U.S. Environmental Protection Agency, Washington, D.C., EPA 530/SW-91-061 (1991).

3. U.S. Environmental Protection Agency "Report to Congress: Solid Waste Disposal in the United States Volume 1", EPA 530-SW-88-011, 1988.

4. U.S. Environmental Protection Agency "Report to Congress: Solid Waste Disposal in the United States Volume II", EPA 530-SW-88-011B, 1988.

5. U.S. Environmental Protection Agency "Results of the Industrial Subtitle D Facility Survey", unpublished, Office of Solid Waste, Washington, D.C., 1987.

6. U.S. Environmental Protection Agency "Toxics in the Community", EPA 560/4-900017, 1990.

7. Science Applications International Corporation "Summary of Data on Industrial Nonhazardous Waste Disposal Practices", Contract 68-01-7050, U.S. Environmental Protection Agency, Washington, D.C., 1985.

8. Smith, M., "Recycling vs. the Paper Industry: An Environmental Argument for Industrial Restructuring", M.S. Thesis, University of California, Los Angeles, 1991.

9. Lockwood-Post "Directory of the Pulp, Paper and Allied Trades", 1990.

10. Chemical and Engineering News, August 5, 1991.

11. Rudd, D. F., Fathi-Afshar, S., Trevino, A. A., and Stadtherr, M. A., "Petrochemical Technology Assessment", Wiley-Interscience, New York, 1981.

12. Chemical Manufacturers Association "CMA Hazardous Waste Survey '88", Chemical Manufacturers Association, Washington, D.C., 1990.

13. U.S. Environmental Protection Agency "Characterization of Municipal Solid Waste in the United States: 1990 Update", EPA/530-SW-90-042, 1990.