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Hazardous Waste Minimization Practices in Tennessee

Belgin Danisman Barkenbus

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ABSTRACT

The minimization of hazardous waste generation as well as the proper treatment and disposal of generated waste has great importance for the protection of present and future human health and the environment. The purpose of this study was to identify the extent of waste minimization practices carried out by Tennessee waste generators since September 1985 and to determine the importance of waste minimization factors as perceived by Tennessee waste generators. This was accomplished methodologically through survey research of large Tennessee waste generators. During the period between August 12, 1987, and October 7, 1987, two mailings and telephone reminders produced a 68.4% response rate from 266 waste generators. The population was categorized in three stratified groupings, based on the quantity of hazardous waste produced: Group One, produced more than 1 million kg per year; Group Two, produced between 100,000 and 1 million kg per year; and Group Three, produced less than 100,000 kg per year but more than 1,000 kg per year.

Data analyses included nonparametric statistical analysis of ordinal level data. Three nonparametric tests were employed: Kruskal-Wallis One-Way Analysis of Variance, Kendall's Coefficient of Concordance, and Somers' d test.

Overall, Tennessee generators, differentiated by the quantity of waste generated, did not differ in their survey responses. However, on individual questions or statements there were some differences. In order to minimize waste, Tennessee generators claimed considerable involvement in process equipment or technology change, company awareness, and "housekeeping" changes. Changes involving the final products were the least applicable or least desirable area for waste minimization. Tennessee generators demonstrated positive response to "voluntary" waste minimization regulations and showed concern for the environment as well. In terms of economics, although cost was an important issue to waste generators, they indicated willingness to adopt some waste minimization practices, even if these were not cost-effective. Waste generators consider their present efforts in waste minimization "moderate" relative to their overall operations. Hence, more minimization of waste is in order.

1. INTRODUCTION

1.1 THE PROBLEM

In the United States hazardous wastes are buried for disposal purposes in numerous land burial sites. As the inventory of hazardous materials grows, the need for disposal sites will increase proportionally. Alternative methods of disposal must be sought and the amount of hazardous wastes must be kept to a possible minimum or the insecure attitude of the public toward hazardous waste disposal will continue.

The public health effects in areas surrounding hazardous waste sites are uncertain and highly controversial (Janerich et al., 1981; Maugh, 1982a; Beck et al., 1983; Kolata, 1980; UAREP, 1986). Measurement and evaluation methods are relatively new and not uniformly agreed upon. Though evidence might not be conclusive, some people who are exposed to various chemicals at these sites report physical and psychological maladies. In some cases, damage is claimed and compensation is obtained (Ember, 1983; Grad, 1985).

Congress passed the Resource Conservation and Recovery Act (RCRA) in 1976 to track hazardous wastes and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, better known as Superfund) in 1980 to respond to spills and other releases of hazardous materials that may threaten human health or the environment from present and deserted dump sites.

RCRA has been amended three times and regulations have been promulgated to interpret these amendments and to resolve hazardous waste disposal problems.

Alternative technologies to landfill have been explored (NRC, 1983; EPA, 1985b; Tucker and Carson, 1985) and also encouraged through government regulations (HSWA, 1984). However, some treatment/disposal options, such as incineration and chemical treatment, will also produce their own wastes that will be disposed at landfills. The better solution must reside in addressing the problem at the generation stage. This involves reducing unnecessary waste production at the source by methods such as good housekeeping and recycling/reuse, as well as decreasing the volume and toxicity of wastes through such means as raw material substitution and process/product modification (HSWA, 1984; NRC, 1985; OTA, 1986).

The most recent (November 1984) RCRA amendments passed by Congress reflect skepticism of the Environmental Protection Agency's (EPA's) diligence in regulating hazardous wastes. These laws were written in the language of regulations, with specific deadlines for required actions. Hence EPA is forced to abide by these deadlines. The amendments, among others, eliminated small generator exemptions (hence included under regulations are those who generate 100 to 100 kg waste per month), barred liquid wastes from landfills, and provided a timetable for the banning of other categories of hazardous wastes from landfills.

One of the amendments, which, in part, is the foundation for this study, dealt with waste minimization. This regulation required generators of waste by September 1, 1985, to certify on the shipping manifest (the shipping paper) that:

1. The generator has a program in place to reduce the volume and toxicity of waste generated to the degree determined by the generator to be economically practicable; and

2. The proposed method of treatment, storage, or disposal is currently available to the generator which minimizes the present and future threat to human health and the environment.

In addition:

1. Once every two years, a report describing the facility's waste minimization efforts and actual amounts reduced needs to be submitted to the EPA and

2. Permits needed for on-site treatment, storage, and disposal of waste must include the Waste Minimization Program (HSWA, 1984).

The regulatory nature of this amendment is unusual. It did not authorize EPA to interfere, investigate, or audit the processes used to minimize waste or to set certain standards or numerical reduction goals that generators were to achieve; rather it left method and standards to the generator's discretion as long as the method chosen was "economically practicable" and "available." Although generators commit themselves to waste reduction by signing the certificate, compliance is in good faith.

Under this amendment EPA was to prepare a report to Congress by November 1986, detailing compliance levels and recommendations for further advancing the waste minimization effort. The five-volume document EPA issued in 1986 to satisfy this requirement recommended (EPA, 1986a,b,c):

1. Deferment of any decision to require performance standards or adoption of specific practices to minimize wastes, and

2. To make its next report to Congress in December 1990.

The study of waste minimization practices can provide evidence of whether progress is being made through this kind of voluntary regulation.

1.2 PURPOSE OF THE STUDY

The purpose of this study was to identify the extent of waste minimization practices carried out by Tennessee waste generators since September 1985 and to determine the importance of waste minimization factors as perceived by Tennessee waste generators.

1.3 THE RESEARCH PROBLEM

The following questions and corresponding hypotheses were stated to identify the extent of waste minimization practices carried out by Tennessee waste generators and to determine the importance of waste minimization factors.

1. Was the quantity of waste generated by Tennessee waste generators independent of employment size or waste stream variability?

Null Hypothesis-1: There Was No Association Between The Quantity Of Waste Generated And Employment Size.

Null Hypothesis-2: There Was No Association Between The Quantity Of Waste Generated And Waste Stream Variation.

2. How did the hazardous waste minimization practice levels of companies vary according to company differences in waste quantity, waste

stream variability, employment size, or major Standard Industrial Classification (SIC) codes?

Null Hypothesis-3: There Were No Differences In Implementation Levels Of Waste Minimization Practices Among The Tennessee Waste Generators As Categorized On The Basis Of Waste Quantity Generation.

Null Hypothesis-4: There Were No Differences In Implementation Levels Of Waste Minimization Practices Among The Tennessee Waste Generators As Categorized On The Basis Of Waste Stream Variability.

Null Hypothesis-5: There Were No Differences In Implementation Levels Of Waste Minimization Practices Among The Tennessee Waste Generators As Categorized On The Basis Of Employment Size.

Null Hypothesis-6: There Were No Differences In Implementation Levels Of Waste Minimization Practices Among The Tennessee Waste Generators As Categorized On The Basis Of Major SIC Codes.

3. Did differing quantity waste generators have distinct waste minimization practices?

Null Hypothesis-7: There Was No Agreement Among The Three Groups Of Tennessee Waste Generators As Categorized On The Basis Of Waste Quantities And The Implementation Level Of Waste Minimization Practices.

4. Was there a relationship between increasing quantities of waste production and waste minimization implementation levels?

Null Hypothesis-8: There Was No Correlation Between The Different Quantity Waste Generators And Different Levels Of Waste Minimization Practice.

5. How did Tennessee waste generators evaluate those waste minimization practices they implemented?

Null Hypothesis-9: There Was No Correlation Between Different Quantity Waste Generators And Their Judgment As To The Extent Of Waste Minimization Practice Levels 4 And 5.

6. How were waste minimization factors (regulations, economics, environmental concerns, and technical knowledge) perceived by Tennessee waste generators of differing waste quantity, waste stream variability, employment size, or major SIC codes?

Null Hypothesis-10: There Were No Differences Of Opinion Among The Tennessee Waste Generators As Categorized On The Basis Of Waste Quantity, Concerning The Influence Of Four Waste Minimization Factors.

Null Hypothesis-11: There Were No Differences Of Opinion Among The Tennessee Waste Generators As Categorized On The Basis Of Waste Stream Variability, Concerning The Influence Of Four Waste Minimization Factors.

Null Hypothesis-12: There Were No Differences Of Opinion Among The Tennessee Waste Generators As Categorized On The Basis Of Employment Size, Concerning The Influence Of Four Waste Minimization Factors.

Null Hypothesis-13: There Were No Differences Of Opinion Among The Tennessee Waste Generators As Categorized On The Basis Of Major SIC Codes, Concerning The Influence Of Four Waste Minimization Factors.

7. Did differing quantity waste generators favor particular waste minimization factors?

Null Hypothesis-14: There Was No Agreement Among The Three Groups Of Tennessee Waste Generators As Categorized On The Basis Of Waste Quantities And Their Perception Of The Importance Of Regulatory Issues.

Null Hypothesis-15: There Was No Agreement Among The Three Groups Of Tennessee Waste Generators As Categorized On The Basis Of Waste Quantities And Their Perception Of The Importance Of Economic Issues.

Null Hypothesis-16: There Was No Agreement Among The Three Groups Of Tennessee Waste Generators As Categorized On The Basis Of Waste Quantities And Their Perception Of The Importance Of Environmental Concerns.

Null Hypothesis-17: There Was No Agreement Among The Three Groups Of Tennessee Waste Generators As Categorized On The Basis Of Waste Quantities And Their Perception Of The Importance Of Technical Know-How Statements.

8. Was there a relationship between increasing amounts of waste production and agreement on factors affecting waste minimization?

Null Hypothesis-18: There Was No Association Between Different Quantity Waste Generators And Their Evaluation Of Each Question Relating To Waste Minimization Factors — Regulations, Economics, Environmental Concerns, And Technical Know-How.

1.4 NEED FOR THE STUDY

During the last 25 years, several environmental protection laws have been passed by Congress and promulgated by EPA. Hazardous waste regulations have constituted an important segment of these laws and regulations. With approximately 300 million metric tons of hazardous waste produced each year in the United States (OTA, 1983) and controversy surrounding its safe disposal, this subject area has sparked intense public concern. Although regulations have tried to produce a system to track waste from "cradle to grave," large noncompliance practices (GAO, 1983a,b) and a great deal of dissatisfaction and uncertainty over safe practices and public health impacts exist (Epstein et al., 1982; O'Hare et al., 1983). All concerned parties (including government agencies, Congress, waste-generating facilities, and the public) have differing perspectives and naturally regard hazardous waste regulations from varying points of view.

Waste generators complain that government is over-regulating (sometimes with overlapping jurisdiction and/or contradictory results) and that the cost of regulations is affecting their business and competitive edge (Greene, 1983; Pashigian, 1984; Willey, 1982; Daneke, 1984; Link, 1982). Some authorities claim that alternative approaches such as common law actions (nuisance, negligence, trespass, and liability laws) and/or industry's self regulation should be considered as alternatives (Baram, 1982; Bardach, 1982; Daneke, 1984; Grumbly, 1982). These authorities would like to see some relief from the governmental regulatory burden.

Much of the public also is not satisfied with current regulations. They seek tougher regulations that would be manifest in specific quantitative targets and specific regulations to meet those targets (Ladd, 1982). Some states developed mediation programs between the public and disposal facilities to alleviate the problem (Bacow and Milkey, 1983).

The Congressional approach highlighted in this thesis is a middle ground between the approaches desired by industry and the public.

If present regulations do not produce results, more stringent requirements could follow. For example a waste-end tax is a strong alternative (CBO, 1985). Environmental regulations with mandatory reduction goals for industry can be passed. More costly record keeping and reporting could become obligatory to monitor compliance.

It is therefore necessary to study the effectiveness of this middle-ground approach to regulations in order to objectively establish whether it can form the basis for a more efficient and cooperative approach to this problem. This type of study will provide input to state and federal lawmakers who establish policies and programs in the waste minimization area to meet the waste management needs of generators and the public.

This area of study deserves attention not only because it is politically controversial, but also because it is one of the most critical issues facing this nation. The most effective policy must be implemented to decrease wastes as the reduction of waste is beneficial for everyone. Today producers of waste must find it within their economic interest to reduce the output of their hazardous wastes. Disposal costs are increasing and litigation threats are real for some companies. Reducing waste will decrease the potential for adverse impacts upon public health, both for the present and for the future. Reducing the generation of waste not only will alleviate disposal problems, but also will lead to a more productive use of national resources and decrease environmental insults. The risk of groundwater and surface water contamination is a major issue. Preservation of these resources is essential for this nation. Consequently, every reasonable effort must be made to decrease waste generation.

There is a limited amount of data and understanding pertaining to industry waste minimization practices. EPA presently hesitates to pass further regulations or to impose unworkable quantitative limits for waste generation/minimization. Although determining the precise extent of waste minimization practices being carried out by industry is not possible at this time, considerable effort should be made toward that goal.

Waste minimization regulations must take account of key decision-making factors influencing industrial program implementation. The role of regulations as well as economic, environmental, and technical factors, and other impending forces must be evaluated for their influence on corporate waste management decision making. Learning more about these factors will lead to recommendations for meaningful regulation.

This problematic area deserves exhaustive examination because of its wide-ranging ramifications. We need to know more about the waste minimization practices of companies and the factors influencing those practices before EPA completes its next report to Congress.

Hence, this study attempts to place the "voluntary waste minimization" requirement within a framework that incorporates waste minimization practices and the range of factors that effect their implementation. Characterization of Tennessee waste generators' waste minimization practices in relation to the amount of waste generated and other subgroup characteristics provides useful insight into what policies may be possible in the future.

1.5 BASIC ASSUMPTIONS

The following basic assumptions were an integral part of this study:

1. The instrument used to collect data was valid and reliable.
2. The returned responses represented waste generating facilities with both good and bad waste minimization programs.
3. The person(s) completing the questionnaire was familiar with the November 1984 amendments to RCRA and the company's waste minimization program and would provide honest responses.
4. Each facility with an EPA ID number was an individual company (although it may have been the subsidiary of a larger company).

1.6 DELIMITATIONS OF THE STUDY

The following parameters have been established for this study:

1. This study included only large Tennessee hazardous waste generators.

2. The population of this study was derived as those generators who identified themselves to the state and federal governments by obtaining an EPA ID number.

3. The 1985 generator list obtained from the Tennessee Department of Health and Education (TDHE) through The University of Tennessee contained the population of Tennessee large waste generators.

1.7 DEFINITIONS OF TERMS

1. Large Waste Generating Facility — Organization that generates 1,000 kg or more of hazardous waste per month as defined in the Resource Conservation and Recovery Act (Public Law 94-580).

2. Groups of Waste Generators — The three groups of large Tennessee hazardous waste generators were: (a) Group One, generates more than 1 million kg per year; (b) Group Two, generates 100,000 to 1 million kg per year; and (c) Group Three, generates less than 100,000 but more than 1,000 kg per year.

3. Waste Minimization Requirement — The intent of Congress as expressed through November 1984 Resource Conservation and Recovery Act amendments (Public Law 98-616) to require waste generators to reduce the amount and toxicity of waste they produce.

4. Voluntary Requirement — Regulations that call for regulatory compliance without specifying quantitative targets or sanctions for noncompliance.

5. Waste Minimization — Reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored, or disposed. It includes any source reduction or recycling activity undertaken by a generator that results in either (a) the reduction of total volume or quantity of hazardous waste, and/or (b) the reduction of toxicity of hazardous waste, so long as the reduction is consistent with

the goal of minimizing present and future threats to human health and the environment (EPA, 1986a).

6. Source Reduction — The reduction or elimination of waste generation at the source. It implies any action that reduces the amount of waste exiting a process (EPA, 1986a).

7. Recycling — The use or reuse of a waste as an effective substitute for a commercial product or as an ingredient or feedstock in an industrial process. It also refers to the reclamation of useful constituent fractions within a waste material or removal of contaminants from a waste to allow it to be reused (EPA, 1986a).

8. Waste Minimization Practice — Implementation of waste minimization as defined in 5 above.

1.8 ORGANIZATION OF THE STUDY

This study is presented in six sections. Section 1, Introduction, consists of eight sections. These are: The Problem, Purpose of the Study; The Research Problem, Need for the Study, Basic Assumptions, Delimitations of the Study, Definitions of Terms, and Organization of the Study. A literature survey on waste minimization and related subjects and methodology is presented in Sect. 2. The methodology and procedures used in this study are explained in Sect. 3. Section 4 contains the analysis and evaluation of the collected data. A summary, findings, conclusions, and recommendations are presented in Sect. 5. Section 6 is a retrospective look at the entire study.

2. REVIEW OF THE LITERATURE

2.1 INTRODUCTION

The major reason this study was undertaken was to analyze and evaluate the progress of generators in response to the voluntary waste minimization requirement that was issued as a November 1984 amendment to the Resource Conservation and Recovery Act. In this section hazardous waste related issues are examined and the findings of existing studies in the waste minimization area are outlined.

2.2 HEALTH EFFECTS

As we learn more about the environmental impacts of chemicals, chemical wastes, and waste landfills, we become more concerned with our physical, social, and psychological health (Beck et al., 1983). The impact of chemicals in the environment on human health is a relatively new field of study. Possible impacts upon the population outside of the work place are much more difficult to substantiate. Difficulties are associated with quantitative assessments of the effects of chemicals from hazardous waste sites and are a complicated issue. There are various parameters to be considered that are hard to control (OECD, 1983; Miller, 1983). From several investigations of health problems at hazardous waste sites (estimated 16,000 abandoned sites), it is concluded that toxic wastes are hazardous. Yet health risk assessments are far from conclusive. They usually cite probabilities determined from adverse health outcomes determined at various places (Houk, 1982; Janerich, 1981; Krieger, 1984; Fiksel, 1986; Greer, 1985; Maugh, 1982a; UAREP, 1986).

The identification of chemicals at dump sites is a problem. There may be few or many different chemicals in different amounts and mixtures. They may have synergistic effects. If they are bioaccumulating, persistent chemicals such as DDT and PCBs, they could be measured in epidemiological studies. However, chemicals not remaining in the tissues are hard to quantify, especially if the study is done long after exposure. Each site needs a site-specific analysis, so the burden of proof rests on the capability and reproducibility of chemical analyses, which is expensive and time consuming.

The evaluation of toxic exposure from disposal sites needs to examine well-defined pathways, such as air. By inhalation and/or skin contact, human beings could be exposed to these toxins. It is not easy to determine if human beings are exposed to these toxins or how far these effects can be traced, as wind and rain can spread toxins. Another critical pathway is internal, through digestion. Hazardous materials can get into our food chain through consumption of plants, animals (fish, poultry, cows), and milk (Ray and Trieff, 1981). The primary concern, however, is drinking water, which might get contaminated through the leakage from hazardous waste land disposal sites to ground water. Internal toxicity of this kind constitutes a much higher health risk than by other pathways (Hileman, 1984; UAREP, 1986; HMCRI, 1985; Bloom, 1985; Evans and Schweitzer, 1984; Dowd, 1985; Weissman, 1984). When chemicals escape into the environment, they can accumulate and persist in fish and organisms, thus causing further risks.

The size and location of the exposed population is not easy to determine. A potentially exposed population does not always stay in the same area for an extended period of time and varies in sex, age, health, and habits (heavy smokers, heavy drinkers, or drug users). Their socioeconomic status is a determinant as well (Josephson, 1983).

No one specific established test exists to base health effects or on which to make measurements. No consensus is reached on what part of the human body or secretion is to be analyzed for the tests. Those chemicals that bioaccumulate in the human body are easier to detect and measure. Urine, blood, fat tissue, human milk, skin oil, or hair measurements are used for sampling to determine concentrations of chemicals. However, some of these have very limited value; others such as adipose tissue, human milk, and hair produce good results with fat-soluble chemicals.

Other health effects are determined by assessing reproductive alterations, chromosomal abnormalities, neurotic effects, and sperm studies. Though these are indicators of exposure, their significance is not known (Maugh, 1982b; Josephson, 1983). Difficulties associated with the epidemiological studies are due to the small size of the exposed population, long or uncertain period between exposure and measurements, and other competing causes for diseases. Waste-site investigations are another assessment method. Several descriptive studies, case-control studies, and cohort studies are other methods used for evaluation (Houk, 1982).

Waste sites are planned to be monitored for 30 years following their closure. The National Research Council considers 500 years as a more realistic period for expected possible hazards from these sites (NRC, 1983). Those living next to a hazardous waste facility or an old dump site obviously are faced with enormous potential health effects. There are well-publicized cases, where people have been evacuated from their homes to avoid further exposure; however, the extent of their present and future health status is uncertain. Some famous cases have been the Love Canal, Times Beach, and others (Kolata, 1980, Ember, 1983; Epstein et al., 1982; Shaw, 1980; Picciano, 1980).

2.3 PSYCHO-SOCIAL FACTORS

Health impact evaluations or risk assessments at hazardous waste sites focus primarily on the biological impacts on humans. Whether or not real biological effects are substantiated by further research, the psychological and social assaults which these people encounter are seldom systematically taken into consideration. Many signs of illness and disease are brought about by social and psychological stress and recognized as a "functional illness" (Twaddle, 1981). Studies during the 1970s demonstrated that an increase in adverse social pressures may closely pre-date the onset of severe mental illness such as schizophrenia or may provoke a relapse (Holdgate, 1982). As indicated by Cohen et al., "helplessness often leads to mental and physical distress independent of the direct impact of an environmental stressor." People who feel exposed to chemicals/toxins (from waste sites/landfills or dumps) feel helpless due to the uncertainty of the situation. There are no well-defined health-effects data or monitoring methods to explain the dose-response relationship. When people do not know the real hazards, they frequently expect the worst. Due to governmental inaction, they often feel cheated or suspect they are not being told the whole truth. Of course they are also aware that their fate will be greatly affected by political decisions and not necessarily by what is best for the public. Various contradictory reports by scientists do not alleviate the problem (Shaw, 1980; Picciano, 1980; Janerich, 1981). People cannot pick up and move due to economic determinants. The reality of their harsh life is that finding another job or selling their now-devaluated house is difficult. For example, the condition of 710 families who were going to be evacuated from Love Canal was described as "very, very frightened and almost panicked" (Holden, 1980). This can easily be substantiated by an incident in which Canal residents kept two EPA officials hostage for several hours. One mental health worker said of residents, "We thought they were going to torch the neighborhood." No doubt people feel desperate in these situations. Many claim the dilemma is worse than being in a natural catastrophe.

Some people faced with stress of this kind start drinking, smoking, and follow life styles leading to poor health. In these situations, family life suffers a great deal. In the 1978 evacuation of Love Canal, it has been estimated that 40% of the 237 families involved have either separated or divorced. Although stress for women and men might be somewhat different, both suffered. Seventeen breakdowns and seven suicides were reported among 550 families a full 10 years before the Love Canal problem was exposed (Holden, 1980).

Although several psychological and social indicators are related to health, government studies still mainly concentrate on carcinogenicity. There is controversy as to whether regulatory actions are taking into consideration the distinction between "risk assessment" and "risk management." Risk assessment deals mainly with the scientific component. Risk management in addition to risk assessment involves broader social and economic policy assessments and weighs policy alternatives (Miller, 1983). A recent National Academy of Sciences report recommended consideration of risk management to obtain the complete picture.

Attempts have been made to compensate victims of exposure. The issue of toxic torts or damage claims for personal injury is inevitable. Some states (California and Minnesota) passed limited laws. A no-fault compensation system may be set up to provide medical expenses and lost earnings to the victims under Superfund. Although clear tort laws have not been passed by Congress, damage suits are piling up and are being awarded in some cases (Ember, 1983; Grad, 1985).

2.4 HAZARDOUS WASTE MANAGEMENT AND REGULATIONS

In the 1960s and 1970s, several environmental laws such as the Clean Air Act, the Clean Water Act, and the Safe Drinking Water Act regulated hazardous materials to a limited extent. However, it was not until the passage of RCRA in 1976 that hazardous materials were subjected to comprehensive regulations. With the passage of this law and the enactment of regulations in November 1980 by EPA, a system was established for tracking hazardous wastes from the time they are generated to the time they are disposed. Hence, RCRA is intended to protect the public and the environment from the adverse effects of hazardous substances. However, there are various exemptions from RCRA wastes, such as household wastes, soil fertilizers used in agriculture, mining wastes, and others. Secondly, RCRA wastes do not include all hazardous materials. Nevertheless these and other omissions are being changed and subsumed under regulation gradually as knowledge of hazardous chemicals increases and new amendments are passed.

Comprehensive regulations for controlling and managing hazardous wastes were further enhanced by another law called Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, 1980), which gave the federal government complete authority to clean up deserted dump sites and to respond to spill or other releases of hazardous materials that may create new waste sites. The Superfund Amendments and Reauthorization Act (SARA) of 1986 significantly broadened EPA's authority in this area (SARA, 1986).

The amount of hazardous waste produced annually in the United States is a matter of controversy. EPA first estimated that a total of

28 to 54 million tons of federally regulated hazardous waste was being produced annually in the early 1980s (OTA, 1983). A 1983 report by the Office of Technology Assessment (OTA) claimed that the EPA estimate was far too low and that the annual figure was instead 255 to 275 million tons, based on a broad study of state officials (OTA, 1983). Even though the figure of 250 million tons generated per year is widely used now, there is still some thought that this is an underestimate (OTA, 1986). With small quantity generators now incorporated within RCRA regulations (by the 1984 RCRA Amendments), even more hazardous wastes must be added to the national total (approximately 1 million tons/year).

The most economical disposal option for companies has been the land disposal of waste (OTA, 1983; EPA, 1987). Due to its economical attraction, this disposal method has been used extensively, thereby discouraging the use of other, more environmentally benign but more expensive, disposal options. The hidden social costs involved in landfill clean up, of course, are not always factored into land disposal costs (ICF Technology, 1984; Booz-Allen and Hamilton Inc., 1983; Maugh, 1979a; Star, 1985; Stanfield, 1985; Gulevich, 1984; Piasecki and Gravander, 1985; Basta et al., 1985; U.S. Congress, 1983).

Congress introduced new amendments in November 1984 to provide further solutions to the existing hazardous waste management problems (HSWA, 1984). These amendments are written more like regulations. At certain dates specified by the Act, they automatically become regulations whether EPA issues them as regulations or not. This method, forced by Congress, was to counter what it perceived to be the time-taking, inefficient ways of EPA and the administration in carrying out the will of Congress.

In the July 15, 1985, Federal Register, EPA also provided regulations with regard to HSWA amendments. There are a total of 12 waste management areas undertaken by the November amendments. Some of the most pertinent subjects addressed were land disposal, waste minimization, and small-quantity waste generator requirements.

1. Small-quantity generators (originally defined as those generating less than 1000 kilograms per month) are now defined as generators producing 100 to 1000 kg of waste per calendar month. By September 22,

1986, they were required to abide by EPA regulations for small generators.

2. Bulk or noncontainerized liquid waste or waste containing free liquids were prohibited in any landfill after May 8, 1985. Effective November 8, 1985, the placement of any liquid which is not a hazardous waste was also prohibited by any landfill. This regulation has led generators to consider alternative disposal methods.

3. Congress also called on EPA to determine whether to ban the land disposal of all RCRA wastes. The land disposal ban is to take effect in several phases. Unless EPA promulgates rules for a list of RCRA wastes (divided into groups based on the hazard and volume of the substances) and provides a schedule for banning them, the provisions set by Congress for banning landfill disposal activate automatically at predetermined dates.

4. The manifest, which is used for hazardous waste shipments, was amended to include additional waste minimization certification by September 1, 1985. A description of the waste reduction efforts undertaken and changes achieved during the year to reduce the volume and/or the toxicity of waste generated is included in biennial hazardous waste reports filed with the EPA and the state.

By this last amendment, Congress emphasized the need to reduce waste. Though presently this area is left in "voluntary" compliance, EPA by November 1, 1986, was required to report to Congress on the success of this program and to provide standards for establishing specific regulations, if necessary.

EPA, in a five-volume report to Congress, fulfilled this 1984 waste minimization requirement but did not call for mandatory waste minimization regulations. Rather, EPA recognized the need for further study and analysis of waste minimization practices and capabilities of industries. In essence, therefore, EPA wanted to leave the waste minimization requirement as is at least until December 1990 (EPA, 1986a,b,c).

2.5 IMPACT OF REGULATIONS

Environmental laws encompassing protection measures for a safe environment rely on the power of the U.S. Constitution, state constitution, federal and state statutes and local ordinances, regulations promulgated by federal, state, and local regulatory agencies, court decisions interpreting these laws and regulations, and common law (Arbuckle et al., 1985). Environmental laws passed to mitigate environmental problems, while improving the environment, have also produced mixed feelings in the chemical process industries. Their heavy-handed nature and impacts have been questioned. This is partly due to the fact that centralized decision making is not popular in the free enterprise championed America (Piasecki and Gravander, 1985). Various European countries (Sweden, Austria, Finland, Netherlands, Germany, and others) have encouraged alternatives to land disposal. They treat their waste before disposal. Their regulations encouraged the implementation of these methods (Piasecki and Gravander, 1985; Piasecki and Davis, 1984; Gulevich, 1984). Manufacturers in the United States believe they know the problems they face and can best solve them without government regulations. However, past experience has shown us that private and nonprivate waste generators brought these problems upon themselves not only by creating them, but by ignoring the possible health effects and the public's reaction. Several well-publicized hazardous waste disposal sites highlighted the poor practices followed by industry in the past (Maugh, 1979a; Epstein, 1982; Hileman, 1983). Love Canal, N.J.; Times Beach, Mo.; and Superfund waste sites are examples of this. Industry has also underestimated the seriousness of the environmental organizations' mission and dedication. Public agencies, various environmental groups, and citizens seek tightened environmental regulations. They want to investigate the neglected practices of certain industries that have abused the environment belonging to both today's and tomorrow's generations. A survey by Chemical Engineering (Basta et al., 1985) indicated that readers felt the chemical process industries do not have the hazardous waste problem under control and that regulations for hazardous waste were adequate but needed better and consistent enforcement.

Public concern and opposition to hazardous waste sites and faulty environmental practices are increasing. Local populations lack confidence in the ability of industry and government to assure public health and safety. Their concern is with unclear risks associated with long-term effects at these sites. People want to be involved in decisions over the construction of waste facilities. In a recent survey (Lyons, 1986) of Tennessee citizens, conducted by The University of Tennessee-based Energy, Environment, and Resources Center, 66% viewed hazardous waste as a "very serious problem." Toxic chemical treatment was seen as more of a problem than low-level nuclear waste, and community veto power over a site was desired.

Presently, the public stand makes finding new waste burial and treatment sites very difficult. Since the issue mainly rests with the states, many states have tried innovative methods to negotiate with local communities on site selection (NGA, 1981; Bacow and Milkey, 1983; O'Hare et al., 1983). In addition to the feelings of various factions, one must look into the implementation and consequences of regulations (U.S. Congress, 1979). It is claimed that regulations have not been effective because their enforcement by the EPA has fallen short of expectations and cannot be done effectively (GAO, 1983a,b; N.Y. Times, 1985; Stanfield, 1984). The enormity of waste generation, the large number of facilities needing inspections, and the limited know-how at EPA are some of the factors that have brought about this problem.

The second reason always cited for noncompliance is the cost issue (NSF, 1981; Pashigian, 1984; Kosters and Simon, 1979). Additional environmental requirements cannot always be met by industry due to the added costs of instrumentation and record keeping. The economy is seen by some to be in decline, and added regulatory cost is shown as a contributing factor (Link, 1982).

A shift of regulatory authority from federal agencies to the individual states is also seen as a cause of conflict for many firms with operations in more than one state (Daneke, 1984). Others think the primary reason for the failure of compliance is due to the failure of studies which did not assess fully the targets of regulations (Durant, 1984). The Congressional directive to force waste generators to find more efficient and effective pollution control technologies by regulations did not meet expectations (Lurie, 1983).

There are some positive features of environmental regulations (Maloney and McCormick, 1982). Regulations have led to some technological innovations and provided a stimulus for new markets and new jobs (NSF, 1981; Ling, 1977, Ruttenburg, 1982).

Overall, RCRA regulations, together with business liability, brought waste generators' awareness of their practices and forced them to set up waste management programs at their facilities (CERCLA, 1980, Piasecki and Gravander, 1985; RCRA, 1976).

Keeping waste minimization regulation voluntary has been supported by recent major studies (EPA, 1986a,b,c; OTA, 1986). Both studies noted that mandatory and uniform reduction targets would be difficult to employ and enforce. Voluntary regulation gives industry a chance to demonstrate what it can do without strict regulation. It also makes economic sense for industries to cut down on their waste, because by waste minimization, disposal costs are lessened and more efficient processes result (NRC, 1985; Mackie and Niesen, 1984).

Some of the wastes can be reduced, recycled, or treated to lessen or to eliminate their hazards. To completely get rid of hazardous wastes or their by-products may not be economically or practically feasible. However, the reduction of waste could be substantial. There are several waste management technologies in existence (Maugh, 1979b,c,d; Pojasek, 1979; Senkan and Stauffer, 1981; Tucker and Carson, 1985; Edwards et al., 1982; Mackie and Niesen, 1984; Budiansky and Josephson, 1980; EPA, 1985b). A publication by the National Research Council (NRC, 1983) entitled, Management of Hazardous Industrial Wastes, identifies the following technologies: (a) 19 different physical processes or unit operations; (b) 11 chemical techniques or unit processes; (c) 13 biological techniques; (d) land treatments; (e) ocean assimilation considerations; (f) incineration; (g) thermal methods; (h) landfills; and (i) permanent storage. It was stated in their recommendations that, "Though there is no one panacea, there currently exists some technology or combination of technologies capable of dealing with every hazardous waste." There are various publications documenting waste minimization of companies as case studies (Huisingh et al., 1986; Weeter et al., 1987; Sarokin et al., 1986).

By minimizing their waste, the potential corporate liability toward those at work and local citizens who come in contact with waste (living around a plant or at waste facilities where their waste is treated) will lessen. By the same token, their liability for potential damage to the environment will be reduced; hence, preventing their waste from becoming a future Superfund site (OTA, 1985).

It will help a great deal if waste minimization can be pursued voluntarily, because it will be hard for EPA to enforce mandatory regulations, and strict regulations might be hard for industry to meet (NRC, 1985; OTA, 1986).

It must also be understood that the intent of Congress is to have "voluntary waste minimization." It is unlawful to certify (on the manifest) that there are waste minimization practices in place, if in reality waste management practices are not geared to reduce the volume and/or the toxicity of wastes.

2.6 STUDIES RELATED TO METHODOLOGY

Major hazardous waste management regulations were first promulgated in November 1980. The first waste minimization requirements, however, were not set forth until November 1984, when Congress passed the HSWA (HSWA, 1984). Based on this law, EPA has, since September 1985, required hazardous waste generators to certify on their hazardous waste manifest that they have initiated a waste minimization effort. The issue of waste minimization, therefore, is of recent origin and few research efforts have been launched to date. Most information in the hazardous waste area has been collected by the EPA and states as part of their regulatory responsibilities. The methodological design part of the limited research will be cited below.

The Chemical Manufacturers Association (CMA) has surveyed its member companies annually since 1981 on their hazardous waste management practices. These surveys have included facilities with SIC code 2800 (Chemical and Allied Products). The 1984 respondents constituted 75% of the major chemical producers (CMA, 1986). These surveys collected quantitative information on company hazardous solid waste and wastewater generation, as well as treatment and disposal practices. Trend analysis has been performed on the responses gathered over the past years.

INFORM, a nonprofit research organization in New York, has conducted research and collected data over three years at 29 organic manufacturing plants. These plants were in three states (California, Ohio, and New Jersey). INFORM has collected its data through interviews with company personnel and through the review of federal, state, and local government agencies' environmental documents. Interviews covering ten specific areas were conducted at 13 of the 29 plants (11 large plants and 2 small plants).

These two studies, seeking to document the extent of waste reduction to date, have shown that measuring waste reduction efforts has been very difficult. Even the materials defined as hazardous wastes in these two studies have been dissimilar. Each has differing survey methods and comes to differing conclusions. INFORM has identified 44 cases of waste reduction practices among 12 facilities. It concluded that overall the amount of waste reduced has been "only a tiny fraction" of the existing volumes for the 29 companies surveyed. On the other hand, CMA reported waste reduction volumes of 22% for 1984 (A 16% average over the four-year survey time) by the 725 industries it has surveyed.

Several surveys have been conducted by the EPA and states to collect waste data from waste generating industries (EPA, 1984; CBO, 1985; GCA, 1980; EPA, 1985a). The Regulatory Impact Analysis (RIA) Mail Survey is a computerized data base that contains the results of two mail surveys conducted nationwide by EPA's Office of Solid Waste. One of these surveys involved the waste generating population (2,000), while the other involved Treatment, Storage, and Disposal Facilities (EPA, 1984; EPA, 1986c). These surveys have collected more than 6,000 data elements describing hazardous wastes generated, as well as management activities of generators. A special emphasis was on waste recycling activities. Through these surveys, company facilities and their SIC codes have been identified (EPA, 1986c). The RIA identifies trends in hazardous waste activities, and sample data are extrapolated for the country as a whole. Since these surveys have been conducted under EPA auspices, generators were required to respond to the data requests.

The Industrial Studies Data Base (ISDB) was also developed by EPA through questionnaires sent to generators (EPA, 1986c). Twelve major industries within the Chemical and Allied Products industry were surveyed. It included 300 facilities. Through this survey questionnaire, information was collected on processes within each industry category. Data were collected on 4,000 waste streams, 500 processes, and 1,000 products.

The statistical reliability of these data bases is debated. The presence of gaps and inconsistencies in the data base is stated, and information is considered somewhat dated (EPA, 1986c). EPA in its report to Congress said that it would develop a national waste minimization data base.

There have been a number of case studies conducted to study in depth the waste minimization practices of individual companies (Huisingh et al., 1986; Weeter et al., 1987). Some of these studies developed a questionnaire to collect data. Weeter developed a nineteen question survey that was sent to thirty companies. Following evaluation, seven of the fourteen companies that responded were visited for in-depth study and analysis.

In 1981, L. H. Kramer developed a list of criteria necessary to gain public approval for developing hazardous waste disposal sites in different communities (Kramer, 1981). This was based on research of three types of disposal sites: a) an on-going facility that had a considerable amount of public approval, b) an on-going site that was under fire from the public, and c) a site that had been chosen by a developer but failed to open due to public outcry.

Kramer chose a sample through telephone interviews of EPA and state officials. Twenty-one cases were chosen as representative, and finally three were selected as crucial for examining the list of criteria. Case studies were developed through interviews, published reports, and newspaper articles.

Ulster County Community College conducted a survey in 1981 for EPA Regions I, II, and III to assess the utilization of the current hazardous waste work force and its future manpower needs (Skaar et al., 1984). A survey form was developed following literature and data base searches and after consultations with EPA and New York State representatives. A supplementary survey form also became necessary to develop because of the consultations. These surveys covered seven types of respondents: Generators; Transporters; Treatment, Storage, and Disposal Facilities; Laboratories; Consulting/ Engineering Firms; Educational Institutions; and Regulatory Agencies. Approximately 3,000 of the 14,305 organizations were chosen nonrandomly for inclusion in the sample for Regions I and II. Response rate to the survey has been disappointing (19% in Region I and Region II and as low as 6% in Region III).

The Chemical Engineering Journal surveyed its readers in the issue published on March 5, 1985 (Basta et al., 1985). Readers were asked questions regarding hazardous waste management practices at their companies. In the September 16 issue, the journal reported receiving 2,000 responses (94.6% from U.S. readers and 5.4% from non-U.S. readers). Respondents included 6% women, and 71% of all respondents had a chemical engineering degree. Fourteen hundred of the respondents actually worked in a plant and three-fourths of these came from plants employing 100 or more workers.

A report by the National Research Council (NRC) identified different levels of waste minimization. It provided a framework for classifying waste minimization activities and analyzed factors affecting their waste decisions (NRC, 1985). The study was done by an ad hoc NRC committee that, by its own admission, lacked a comprehensive and systematic data base on the amount of waste reduction and extensive peer-reviewed literature on the nontechnical aspects of waste reduction. The report was generated by examining previous reports on waste reduction and through extensive discussions with experts at a workshop.

OTA's extensive 254-page report, Serious Reduction of Hazardous Waste, contains considerable waste information as well as an assessment of technical, economic, and policy concerns in waste reduction (OTA, 1986). It emphasizes that the solution to the waste problem lies in source reduction before waste is produced and not in its management after it is formed. It offers several major steps for industry and

Congressional consideration. OTA carried out the study through the use of government documents, reports, workshops, and the use of a survey.

In 1986, OTA nonrandomly surveyed waste generators on waste minimization issues (OTA, 1986). Ninety-nine of the 141 firms (in 20 states) that were surveyed responded to the questionnaire. Questionnaires were mailed to waste generators and also distributed to participants in OTA workshops. Forty-three of these respondents classified themselves as small or medium waste generators and 56 as large generators.

The survey instrument prepared by OTA was in a checklist and Likert-type format. It had three sections: section one collected status information; section two collected data on the company's past waste minimization efforts, as well as their opinions on waste minimization issues; and section three asked questions on possible future actions for both companies and government.

Another extensive study of waste minimization was EPA's five-volume report to Congress required by the HSWA of 1984 (EPA, 1986a,b,c).

These five volumes were based on government and private sector documents and other available data bases. Results from a survey of 22 industrial processes were also included in the report.

In volumes I and II, EPA reviewed the desirability and feasibility of establishing additional requirements for waste minimization under RCRA. In the remaining volumes, EPA identified waste minimization practices in the United States by major industry processes and major waste streams. Incentives and disincentives for adopting waste minimization practices, as well as strategies to increase it, were identified.

In this section a thorough literature review was undertaken to elaborate hazardous waste management aspects: (a) health effects, (b) psycho-social factors, (c) hazardous waste management regulations, (d) the impact of regulations, and (e) studies related to methodology. These sections provided a focus for the research that followed.

3. METHODOLOGY

3.1 INTRODUCTION

Numerous environmental regulations have been proposed and passed by Congress in recent years and promulgated by the appropriate administrative agency. As discussed in previous chapters, the hazardous waste minimization amendment was unique by virtue of its "voluntary" status. This study collected information on waste minimization practices of Tennessee hazardous waste generators adopted since the waste minimization amendment went into effect and to analyze the reasons for their adoption. To investigate the areas of concern, the following methodological steps are outlined: (a) Population and Sample Selection, (b) Instrumentation, (c) Data Tabulation and Statistical Analysis, and (d) Summary.

3.2 POPULATION AND SAMPLE SELECTION

The population of this study included Tennessee's large hazardous waste generators who generated 1000 kg or more of RCRA hazardous waste per month. As a large generator each was required to abide by all interim and/or final status requirements as stated in Title 40 of the Code of Federal Regulations.

The list of population data used was that of the state of Tennessee Department of Health and Environment (TDHE). Since the Waste Minimization certification requirement for the manifest went into effect on September 1, 1985, the 1985 list of generators was chosen to be included in this study. The 1985 TDHE generator list was obtained from The University of Tennessee (UT), Waste Management Research and Education Institute, which has ongoing research for the TDHE and where the TDHE generator list was on a computer data base.

The study population included all Tennessee large RCRA waste generators who ship waste off-site and/or treat waste on-site. There were 577 generator entries on the 1985 TDHE generator list. However, an additional 41 generators were identified on the TDHE Biennial Report to the EPA (TDHE, 1986b) and were listed as generators who did not file an annual report with the state. Although the TDHE list was considered comprehensive, discrepancies were expected. Probably some waste generating facilities went out of business since 1985 or never reported to TDHE, being in noncompliance with the RCRA requirements. However these were expected to be a small segment of the population. Telephone follow-up of nonrespondents reduced most of the first concern. For the second concern, it had been 5 years since RCRA went into effect (since November 1980). Consequently, generators were familiar with this regulation and the noncompliance rate for obtaining an EPA ID number was expected to be very low. Because of the various registration requirements it was hard for manufacturers to avoid obtaining waste ID numbers indicating they were waste generators. If they were waste generators, they had manifest requirements tracking generated waste from generator, to transporter, to disposer. Due to legal and environmental penalties, avoidance of these practices would be very costly. And finally, the companies that could avoid obtaining an ID number probably were generating extremely small amounts of waste. Conversations with the TDHE staff (Mr. Ron Graham, Environmental Engineer, May 25, 1987) revealed that there were probably some small generators on the large generator list as well as some large waste generators that did not generate hazardous waste now. Consequently, the researcher took the following steps and eliminated generators who were not within the purview of this research:

- Fourteen generators which were listed in the TDHE 1985 Biennial Report to the EPA as nonhazardous waste generators (TDHE, 1986b).

- One hundred sixty-three generators which were identified as small generators by a TDHE computer printout provided to UT (TDHE, 1986b). However 32 of these generators which generated 12,000 kg in 1985 were included (TDHE list provided by UT). As a result, using a conservative approach only, 131 small generators were excluded.

- Twenty-five generators on the 1985 TDHE generator list which were not marked as small generators but generated less than 1,000 kg waste per year.

Following these adjustments, a total of 407 hazardous waste generating facilities was determined for this study.

Tennessee waste generators were expected to be heterogeneous but exhibit certain patterns. It was observed from the TDHE generator list that a relatively few generators produced a majority of the waste. A larger number of generators produced considerable but not inordinately large amounts of waste. Finally, many more generators produced much less waste. Consequently, on the basis of waste totals, three groups were formed at natural break points.

The total population of 407 waste generating facilities was stratified into three categories on the basis of the quantity of waste generated per year. These categories were (a) more than 1,000,000 kg per year, (b) 100,000 to 1,000,000 kg per year, and (c) 1,000 to less than 100,000 kg per year. These categories were based upon feedback obtained from the TDHE (Graham, 1987). These were natural break points that described generators based upon the Superfund fee collection system used by the state. Stratification on this basis produced 58 generators in the first category, 82 generators in the second category, and 267 in the third category, respectively. Since the population for the first two groups was small and a low response rate was anticipated (Sarokin et al., 1986; Skaar et al., 1984), the entire population of the first two groups was included in the sample size. A sample size of 50% (N = 134) was selected from the last population group to examine its properties. Since the sample from the last category was taken randomly, it was a representative sample. Random sampling was implemented without replacement. This sampling size was believed to be large enough to overcome the suspected low return rate. In addition, the sample size of 274 was found to be acceptable and to provide high enough returns in each group for statistical evaluations.

The TDHE list containing waste production amounts was listed by EPA ID number. Name, phone number, and contact person for each company was matched using another TDHE computer printout (TDHE, 1986b). The address information was obtained by utilizing the Directory of Tennessee Manufacturers (Smith Publishers and Printers, 1986; 1984). In some cases, addresses were obtained over the phone.

3.3 INSTRUMENTATION

The hazardous waste minimization subject was relatively new and received considerable attention only after Congress passed the 1984 Hazardous and Solid Waste Amendment (HSWA, 1984). Existing research was very limited in nature. It existed more in the form of case studies or in identification of technologies for waste minimization. There was no instrument to be utilized. Hence, the survey questionnaire was developed to study the impact of the voluntary waste minimization regulation on hazardous waste generators in regard to their waste minimization practices and to their perception of waste minimization factors for adopting these practices.

3.3.1 Construction of the Survey Instrument

A comprehensive review of the literature and government documents on waste minimization was used in constructing the survey instrument. The Office of Technology Assessment's survey form, administered in two workshops and sent to industry personnel in February and March of 1986, was especially useful (OTA, 1986). Textbooks on question preparation were consulted (Sudman and Bradburn, 1986; Dillman, 1978; Sheatsley, 1983). Experts who were familiar with waste issues or who had conducted research in other waste-related areas also contributed to the development of the preliminary draft of the questionnaire. The instrument was constructed to collect information on facilities' waste minimization practices and their perception of four contributing factors to the waste minimization activities after the 1984 RCRA amendment went into effect. Three sections were developed to collect information and to measure desired statistics. For each section, questions were prepared either to identify independent variables or to measure desired dependent variables. After the instrument was judged to have content validity by the researcher, it was offered to the panel of experts.

A panel of experts was selected by the researcher to review the survey instrument (Appendix A). Panel members were chosen on the basis of their knowledge and experience in the waste minimization and waste management fields, their familiarity with regulatory requirements, and instrument construction. To provide diverse backgrounds, efforts were made to include members from the government, business, and academic communities.

A form was developed for the expert to evaluate the instrument. Experts were asked to review the instrument and judge the validity of each major item on the basis of its substance, grammar, clarity, objectivity, and usability. Each member received: (a) a copy of the instrument, (b) the criteria evaluation form, and (c) an addressed and stamped envelope for their responses.

When there were questions or objections raised by the experts, the researcher contacted members individually to clarify these areas and to obtain a clear interpretation. All comments, suggestions, and objections were evaluated by the researcher and then incorporated in the final draft of the instrument.

The final draft version of the instrument, consisting of three main sections, was designed to test major hypotheses of the study. Each item was prepared with the intention of collecting the most relevant data.

Section 1 items were designed to collect data on the status of the waste generating company. Facilities were asked questions such as size, variability of waste streams, and SIC codes. These items were used in describing and grouping facilities into various subgroups. There was not any accepted grouping for the size of the company by employee number. Various categories were used depending upon the particular manufacturing industry and sector. Size category also changed by city (Tennessee Statistical Abstracts, 1987; County Business Patterns, 1987; Conversation with Melissa Mundel of Knoxville Chamber of Commerce, July 22, 1987). U.S. Statistical Abstracts divided employee size and class into three groups using breaks of 0-19, 20-99, 100-249, 250-999, and 1000 and above. Since there was no uniform ranking, a modified version of this division was adopted in the waste minimization survey instrument. A table listing waste types was provided for respondents to reply as to the number of waste streams produced (CBO, 1985).

Section 2 questions were designed to determine the extent of facility waste minimization practices since the passage of the waste minimization amendment. Nine categories were used to identify the respondent's practices. One question evaluated the extent of these practices.

Section 3 was constructed to obtain a ranking of the four waste minimization factors by the companies. Section 3 sought to ascertain which factors were most important for companies adopting waste minimization practices. Four factors were viewed separately as possible influential agents: (a) regulatory, (b) economic, (c) environmental, and (d) technical factors. Each factor's influence was measured by responses to the questions listed under each category.

A combination of scales was used in the instrument; however, the Likert scale was the dominant one.

Section 1 was constructed in an item format. Respondents were provided with space to fill in an answer or asked to check yes or no boxes.

Section 2 was constructed on a Likert scale. The five levels of scale measured the implementation levels of waste minimization practices.

Section 3 was constructed on a Likert scale. Five levels of respondent agreement were matched with the amount of waste generated at the facility. The Likert scale categorized generator input on a five-level agreement scale.

At the end of each section a place was provided for "additional comments."

When the instrument was judged to be satisfactory by the researcher, a test was performed to ascertain its overall utility and reliability in the real setting. The researcher chose to conduct a pilot study at the conference titled "International Congress on Hazardous Materials Management" at Chattanooga (June 8-12, 1987). During the conference a survey form was pretested by eight Tennessee and two out-of-state waste generators. Pretest objectives were to evaluate the instrument for comprehension and time expended. Space was included below each question to measure the participant's comprehension and solicit suggestions for new wording. Following completion of the form, six questions were asked. In addition, the researcher informally interviewed each participant who completed a form.

The results of the pilot study were obtained and treated for data tabulation and statistical analysis. The comments were incorporated following their evaluation by the researcher.

The resulting pretested questionnaire was further evaluated, analyzed, and organized by the researcher to ensure its validity and interpretability. At this point the instrument was judged completely satisfactory for use in the research study (Appendix B).

3.3.2 Survey Protocol

A mail questionnaire was selected as the primary means to collect data in a cross-sectional study to evaluate hazardous waste minimization practices and reasons for their adoption. The mail survey asked hazardous waste generators who were affected by the 1984 RCRA amendment to voice their opinions on the reasons for adopting waste minimization practices and to provide an overall measurement of the waste minimization efforts implemented by the generators. A written questionnaire provided generators with anonymity in answering site-specific questions and permitted use of standardized questions. However, some leeway was included by providing space to write additional questions or comments, and to aid the collection of as much information as possible.

The survey instrument and the survey protocol included various steps recommended for mail surveys (Dillman, 1978; Backstrom and Hursh-Cesar, 1981). The following techniques were utilized in the design of this survey research:

1. The survey questionnaire was constructed in a short and concise, but comprehensive manner, with clear instructions to minimize time necessary to complete it.

2. The front page included an attractive title and an illustration. The back page did not contain any questions but only requested additional comments (Dillman, 1978).

3. A cover letter was used to establish the credibility of both the study and the researcher (see Appendix C). The study and its intent was explained in order to eliminate any prejudice or reservations respondents might have in completing the form. The cover letter ensured the confidentiality of the survey.

4. The cover letter included two additional signatures besides the researcher's. This was done to encourage participation and to enlist support and backing for the project. The signature of the UT director of Waste Management Research and Education Institute and that of an official from the Tennessee Association of Business provided such support and backing for the project.

5. To enhance the return rate the instrument was printed on light yellow paper, since this was recommended in various studies as a factor in improving the return rate.

6. Survey packages were sent by First Class Mail.

7. A preaddressed, stamped envelope was included with the questionnaire for the return of responses.

8. Another copy of the instrument with a follow-up letter (see Appendix D) and a preaddressed, stamped envelope was mailed to the entire survey population as a reminder three weeks following the initial mailing date of the instrument.

9. Postcards (illustrated in Appendix E) were mailed to all surveyed population to encourage further participation. This was done a week after the mailing of the second survey packages.

10. A telephone follow-up strategy was utilized as another means of increasing survey returns and of characterizing the nonrespondent three weeks following the second mailing date of the instrument.

3.4 DATA TABULATION AND STATISTICAL ANALYSIS

3.4.1 Data Tabulation

The collected data were tabulated at the end of the survey period. For better organization of information, preliminary data analysis included some common descriptive statistical analysis. The percentages pertaining to subgroups were calculated to present a general overview of the sampled population using status information data.

In order to test the research hypotheses, the sample was broken into subgroups for the following independent variables:

1. the amount of waste generated per year,
2. the variability of waste streams generated at the facility,

3. different sizes of employment at companies, and

4. major SIC codes.

Data were also differentiated in terms of the following dependent variables that were the focus of study for measurement:

1. the waste minimization practices adopted since September 1, 1985, and

2. the four factors (regulatory, economic, environmental, and technical) influencing waste minimization practices.

The subgroups for independent variables were established. These are explained below.

Tennessee generators were separated into three groups according to the amount of waste generated per year. These groups were

1. more than 1,000,000 kg,
2. from 100,000 to 1,000,000 kg, and
3. from 1,000 to less than 100,000 kg.

To compare waste minimization practices in terms of variability in waste streams, sampled populations were identified as:

1. 1 to 3 waste streams,
2. 4 to 10 waste streams,
3. 11 and above waste streams.

Employment size was subdivided as follows:

1. 1 to 99 employees,
2. 100 to 999 employees, and
3. 1000 and above employees.

3.4.1 Statistical Treatment

This research utilized probability sampling, which was stratified random sampling. The researcher collected data by using ordinal level of measurement. (Ordinal level of measurement provides quantitative data by assignment of ranks to measured variables.) Ordered categories of measurement were constructed by the researcher. For the waste minimization practices, scale was constructed for the increasing level of implementation of waste minimization practices, and this level varied from "implementation with quantifiable results" to "not evaluated or not applicable." For waste minimization factors, measurement levels ranged from "strongly agree" to "strongly disagree" (Appendix B, Survey Form).

Nonparametric statistical methods were preferred over parametric methods to test the hypotheses of this research. This preference was based on the ordinal level of measurement of data, uncertainty of fulfilling strict normal distribution, and homogeneity of variance requirements.

This study was conducted to identify the extent of hazardous waste minimization practices of Tennessee waste generators and to determine the importance of selected waste minimization factors as perceived by Tennessee waste generators. The researcher analyzed results in total as well as on the basis of the variable waste quantity. More specifically, the independence of the three populations from which the three samples were taken — namely, the three groups that were categorized by quantity of waste generated — was tested. By a statistical method, it was determined if differences among sample values mean genuine population differences or if they were from the same population and if the differences were due to chance variations (Siegel, 1956). Kruskal-Wallis One-Way Analysis of Variance for k independent samples was used to determine if the three samples were from different populations.

If the proposed Null Hypothesis was accepted, it was decided that the three populations from which the samples were taken were from the same or identical populations and there was no difference among measured values (waste minimization implementation levels or agree-disagree spectrum). Even though three independent samples had the same distribution (same means), the shapes were not required to be normal (Agresti and Finlay, 1986). If the proposed Null Hypothesis was rejected, it implied that the chances were less than 5 out of 100 that the three populations were alike. Consequently, this meant that the independent groups of generators were not the same in their waste minimization implementation levels or in their perception of waste minimization factors (response variables were not independent of groups).

The formula used for the Kruskal-Wallis test was provided by Siegel (1956) as:

$$H = \frac{12}{N(N + 1)} \sum_{j=1}^{k} \frac{R_j^{\,2}}{n_j} - 3\,(N + 1) \quad ,$$

where

N = the number of cases in all samples,

k = the number of samples,

n_j = the number of cases in the jth sample,

R_j = the sum of ranks in jth sample (column).

In this test, all scores were ranked and the rank of one was assigned to the lowest score and the largest rank to the highest score. The sum of ranks was determined for each sample (R_j). The Kruskal-Wallis test determines from the sum of ranks for each column if they were likely or not to have come from samples that were drawn from the same population. Since there were more than five scores in groups ($n_j > 5$), H statistic was distributed as chi-square. Degrees of freedom was represented by $df = k - 1$. When H is equal or larger than the value of chi-square for the level of significance, the Null Hypothesis was rejected.

During the ranking of scores, scores might tie. For these cases, each score was given the mean of the ranks for which it was ranked. To correct for ties, the formula for H given above was divided by:

$$1 - \frac{\sum T}{N^3 - N} \quad .$$

The formula for T was:

$$T = t^3 - t \quad ,$$

where t = the number of tied observations in a tied group of scores.

H corrected for ties was given by the formula below:

$$H = \frac{\dfrac{12}{N(N + 1)} \displaystyle\sum_{j=1}^{k} \frac{R_j^{\,2}}{n_j} - 3\,(N + 1)}{1 - \dfrac{\Sigma\, T}{N^3 - N}} \quad .$$

Secondly, the researcher wanted to study the association among sets of rankings of three groups of generators. Kendall's Coefficient of Concordance, W, provided the degree of association (agreement) among these variables. Perfect agreement among the groups would result in Kendall's Coefficient of Concordance, W, of one. No agreement would yield a W equal to zero. By this method, the mean scores of N questions by k different attributes were assigned rankings. The largest rank was assigned to the largest mean in each k sets of rankings (i.e., indicative of that item having the highest waste practice implementation or agreement on waste minimization factors).

Kendall's Coefficient of Concordance, W, was given by the following formula (Siegel, 1956):

$$W = \frac{12\,S}{k^2(N^3 - N)} \quad ,$$

where

S = the sum of squares of the observed deviations from the mean of the sum of ranks, R_j,

$$S = \sum \left(R_j - \frac{\Sigma R_j}{N} \right)^2$$

k = the number of sets of rankings,

N = the number of entities ranked.

The chi-square value was calculated from W by a formula:

$$X^2 = k\ (N - 1)\ W \quad .$$

Calculated chi-square values were assessed for testing the significance of the association, W, using a chi-square table for df = N − 1 at 0.05 level of significance.

The association between two variables was measured using Somers' d. The procedure was based on the difference between the numbers of concordant and discordant pairs. This test was used for ordinal measures of association and described the extent of the subject ranking on two different variables. This association takes on values between −1 (perfect negative association) and +1 (perfect positive association). Somers' d did not assume that ordinal measures of association were symmetrical. Hence, their values were based on the identification of dependent and independent variables (Agresti and Finlay, 1986).

The hypothesis that X (independent variable) causes or predicts Y (dependent variable) was given by the formula (Garson, 1971):

$$d = \frac{P - Q}{P + Q + X_o} \quad ,$$

where

P = concordant pairs of observations,

Q = discordant pairs of observations,

X_o = number of pairs tied on independent variable but not on dependent variable.

The statistical significance of Somers' d was tested by the Z statistic. The normal approximation to the distribution was assumed as an application of central limit theorem (Conover, 1971). The values obtained for Somers' d were divided by the approximate standard error (Agresti and Finlay, 1986). The Null Hypothesis was rejected at the 0.05 level of significance when the absolute value of Z was equal or greater than 1.96.

These tests will be applied and explained in detail in Sect. 4 where the variation in waste minimization practices and factors will be studied.

3.5 SUMMARY

This section has set forth the discussion of methods that were used in implementing the study. The population of the study and the instrument used in measurements were described. Due to the special emphasis on creating a new instrument, validation, the pilot study, and the tactics of increasing response rate were included in detail. Dependent and independent variables and subgroups utilized in information gathering and in calculations were clearly identified. Due to the nature of the study and scales of measurement, nonparametric statistics were used. The Kruskal-Wallis test for determining if samples came from the same population, the Kendall's Coefficient of Concordance and Somers' d test were chosen for statistical treatments. The 0.05 level of significance was used in statistical comparisons. Section 4 describes the results of the collected data and detailed statistical analysis.

4. ANALYSIS OF THE DATA

4.1 INTRODUCTION

Data collected by conducting a mail survey of 274 Tennessee large hazardous waste generators were analyzed for descriptive and inferential statistical relationships. Tennessee waste generators were stratified into three categories on the basis of the amount of hazardous waste generation. They were: in Group One, 58 generators generating more than 1 million kg per year; in Group Two, 82 generators producing 100,000 to 1 million kg per year; and in Group Three, 134 generators with less than 100,000 but more than 1,000 kg per year.

The 274 survey forms forwarded to facilities (twice) produced 190 responses. Eight of these generators who identified themselves as "small generator" or "nongenerator" were not included in the sample. As a result, 182 responses from 266 waste generators produced a 68.4% response rate.

Data were analyzed using the SAS BASE-27 and SAS STAT 195 systems on a personal computer (SAS system under PC DOS Release 6.02) and SPSS at The University of Tennessee.

This section is organized into the following sections: (1) introduction, (2) sample description, (3) data presentation, and (4) summary.

4.2 SAMPLE DESCRIPTION

The survey instrument was mailed to 274 waste generators twice in a three-week interval, first on August 12, 1987, and second on September 2, 1987. After a second response period, attempts were made to contact nonrespondents (from September 23, 1987, to October 7, 1987).

Table 4.1 shows the distribution of responses from the three waste generating groups. The 45.1% response rate obtained from the first mailing increased to 68.4% by the second mailing and telephone contacts. Of the 182 respondents, 43 were from Group One, 50 from Group Two, and 89 from Group Three. The preponderence of Group Three respondents was due to the large sample size selected from Group Three to

Table 4.1. Survey response rate of Tennessee hazardous waste generators

Waste quantity categories	Sample size	Responses received through initial mailings 8/12/87–9/2/87	Responses received through second mailing 9/2/87–9/23/87	Responses received through telephone survey 9/23/87–10/7/87	Total	Percent
Group 1[a]	58	26	15	2	43	74.1
Group 2[b]	80[c]	36	14		50	62.5
Group 3[d]	128[c]	58	26	5	89	69.5
Total	266	120	55	7	182	

[a]Facilities producing more than 10^6 kg per year.

[b]Facilities producing $10^5 - 10^6$ kg per year.

[c]Sample excludes those generators who identified themselves as non-generators or small generators through mail or phone surveys.

[d]Facilities producing $10^3 - 10^5$ kg per year.

overcome an expected low return rate. However, the high response rate by Group Three indicated just as much interest and desire to participate in the survey as those generators producing more waste. Consequently, a smaller sample size could have been obtained from Group Three for this study. The highest response rates were obtained from Groups One and Three of the Tennessee large waste generators, 74.1% and 69.5%, respectively. The Group Two response rate was 62.5%. As can be seen, the amount or volume of waste generated did not account for significantly different response rates.

At the end of September 23, 1987, there were 91 (17 in Group One, 30 in Group Two, and 44 in Group Three) nonrespondents. Although efforts were made to reach all the nonrespondents by telephone at least once, only 46% of nonrespondents were contacted.

Table 4.2 shows the distribution of nonrespondents as categorized by their reasoning for nonresponse. The highest nonrespondent input was obtained from Group One (52.9%) and the lowest from Group Three (43.2%). However, overall, 21.4% of the nonrespondents contacted were from Group One, 33.3% from Group Two, and the largest, 45.2% of the contacts established were from Group Three generators. Although a lesser percentage of the Group Three respondents were contacted, they constituted a larger portion of the overall contacts.

Individuals completing the form were involved in the field of waste management and familiar with the waste minimization program of their companies. The titles of the respondents indicated that they were mainly plant or waste managers, health and safety experts, or engineers. Additional comments were made, which were included in Appendix F.

The response rate was far more favorable than expected. This can be attributed to the interest in the subject, as well as proper instrument construction and follow-up.

Those generators that identified themselves as small generators or nongenerators were not included in the overall rate calculations (eight generators). Responses received after the cut-off date of October 14, 1987, were also not included in the results.

Employee distribution within the three groups of respondents is presented in Table 4.3. Respondents were asked to indicate their size

Table 4.2. Reasons cited by nonrespondents for their nonresponse

Waste quantity categories	Sample size	Time constraints	Neglect[a]	Not hazardous waste generator	Contact person moved	Small generator	Did not want to	Sold business	Total	Percent
Group 1[b]	17	1	4		1		2	1	9	52.9
Group 2[c]	30	2	2	2	6		1	1	14	46.7
Group 3[d]	44	2	8	3	2	3	1		19	43.2
Total	91	5	14	5	9	3	4	2	42	

[a]After contact, seven of the fourteen (2 from Group 1 and 5 from Group 3) completed and returned the questionnaire and were included with the respondents.

[b]Facilities producing more than 10^6 kg per year.

[c]Facilities producing $10^5 - 10^6$ kg per year.

[d]Facilities producing $10^3 - 10^5$ kg per year.

Table 4.3. Distribution of Tennessee waste generators by number of employees and quantity of waste generation

Number of employees	Waste quantity categories			All respondents	Percent
	Group 1[a]	Group 2[b]	Group 3[c]		
0—99	10	15	29	54	29.7
100—999	24	29	51	104	57.1
1000 and above	9	6	9	24	13.2
Total N	43	50	89	182	100.0

[a]Facilities producing more than 10^6 kg per year.

[b]Facilities producing $10^5 - 10^6$ kg per year.

[c]Facilities producing $10^3 - 10^5$ kg per year.

within the following three groupings: 0-99, 100-999, and 1000 and above. The largest number of waste generators were in the grouping 100-999 (57.1%). The major employment category for each waste generator grouping also concentrated in the 100-999 range. Column percentages indicate that all three groups had approximately the same number of firms with employment in the 100-999 category (Fig. 4.1).

In Table 4.4, waste amount groupings were compared to the number of waste streams firms were generating. Respondents made their selection of waste streams from a table provided with the survey form (Appendix B). Overall, 61.5% of waste generators had 1 to 3 kinds of waste streams, 33.5% had 4 to 10 kinds of waste streams, and only 5.0% had 11 or more distinct waste streams. Nearly half (48.8%) of the Group One generators had from 4 to 10 waste streams (Fig. 4.2). In addition, compared to the other groups, Group One had a large number of firms with 11 or more waste streams. These findings indicate that a greater variety of waste streams were present in the largest waste producing group.

Ninty-five percent of the generators indicated sending wastes to off-site disposal facilities (Table 4.5). Only 5.0% did not use off-site disposal facilities. Differences between the groups on this measure were not notable. While the vast majority of generators indicated sending waste off-site, it cannot be determined from the survey what quantities are transported off-site.

There were 28 different two-digit SIC codes represented in the sample (Table 4.6). The four most common SIC codes found in the sample were SIC codes of 34 (22.0%), 28 (14.3%), 35 (10.0%), and 33 (7.7%). These industries, constituting 54% of the sample, were Fabricated Metal Products, Machinery, Chemical and Allied Products, and Primary Metal Industries.

4.3 DATA PRESENTATION

In this section independent variables, waste minimization practices, and four waste minimization factors (regulatory, economics, environmental, and technical) are explored in detail. The waste

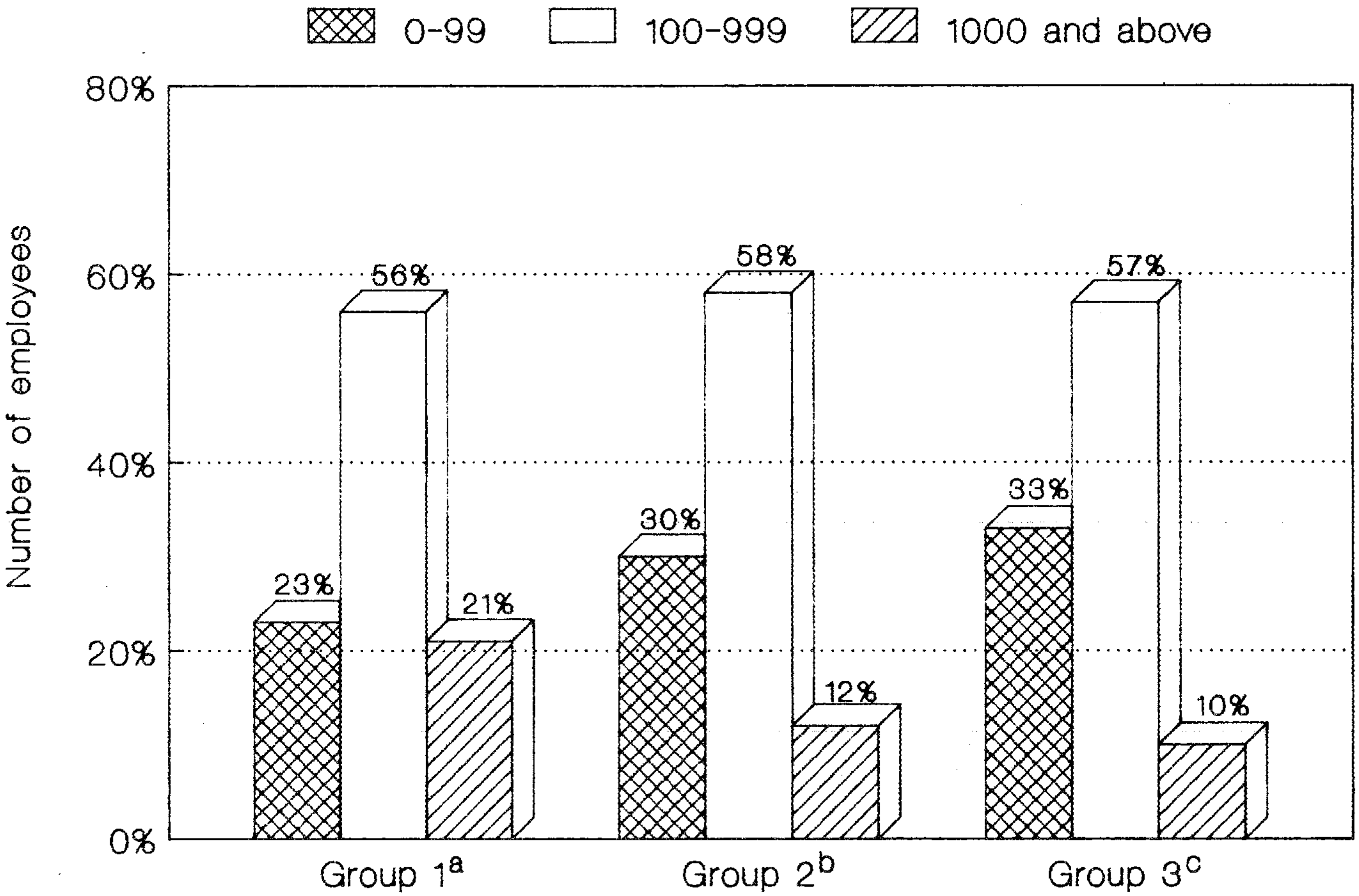

Fig. 4.1. Waste groups by number of employees.

[a]Facilities producing more than 10^6 kg per year.
[b]Facilities producing 10^5 - 10^6 kg per year.
[c]Facilities producing 10^3 - 10^5 kg per year.

Table 4.4. Distribution of Tennessee waste generators by number of waste streams and quantity of waste generation

Number of waste streams	Waste quantity categories			All respondents	Percent
	Group 1[a]	Group 2[b]	Group 3[c]		
1 to 3	16	36	60	112	61.5
4 to 10	21	12	28	61	33.5
11 and above	6	2	1	9	5.0
Total N	43	50	89	182	100.0

[a]Facilities producing more than 10^6 kg per year.

[b]Facilities producing $10^5 - 10^6$ kg per year.

[c]Facilities producing $10^3 - 10^5$ kg per year.

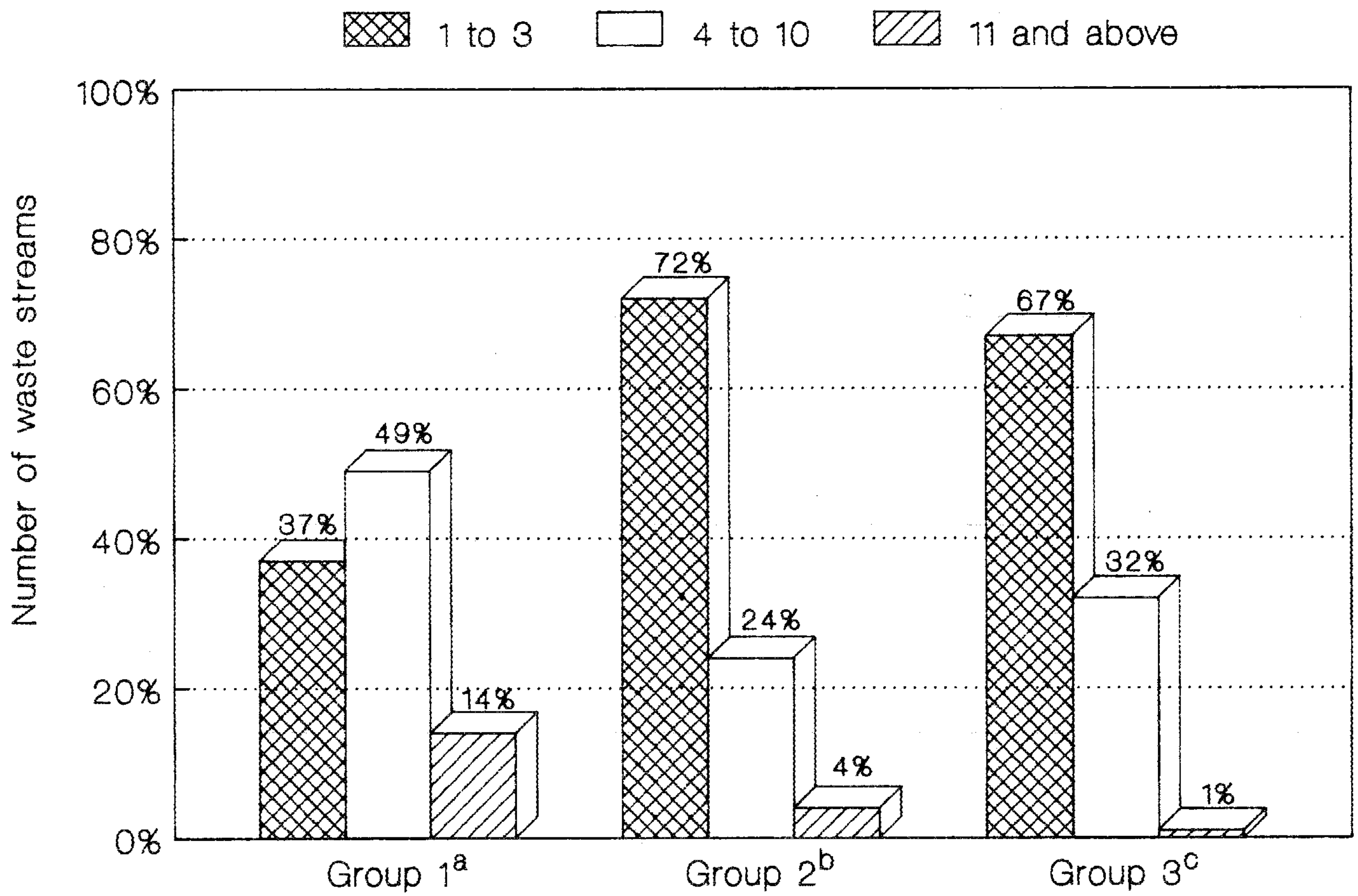

Fig. 4.2. Waste groups by number of waste streams.

[a]Facilities producing more than 10^6 kg per year.
[b]Facilities producing 10^5 - 10^6 kg per year.
[c]Facilities producing 10^3 - 10^5 kg per year.

Table 4.5. Distribution of Tennessee waste generators according to shipment of waste and quantity of waste generation

Waste shipments	Waste quantity categories			All respondents	Percent
	Group 1[a]	Group 2[b]	Group 3[c]		
Facilities sending wastes to off-site TSDFs[d]	41	45	87	173	95.0
Facilities not sending waste to off-site TSDFs[d]	2	5	2	9	5.0
Total N	43	50	89	182	100.0

[a]Facilities producing more than 10^6 kg per year.

[b]Facilities producing $10^5 - 10^6$ kg per year.

[c]Facilities producing $10^3 - 10^5$ kg per year.

[d]Treatment, storage, and disposal facilities.

Table 4.6. Distribution of Tennessee waste generator respondents by two digit SIC[a] codes

SIC codes	SIC title	Number of respondents
12	Coal mining	1
20	Tobacco products	1
22	Textile mill products	2
23	Apparel and other finished products	1
24	Lumber and used products	4
25	Furniture and fixtures	6
26	Paper and allied products	8
27	Printing, publishing, and allied industries	6
28	Chemical and allied products	26
30	Rubber and miscellaneous plastics	7
31	Leather and leather products	1
32	Stone, clay, glass, and concrete products	3
33	Primary metal industries	14
34	Fabricated metal products	40
35	Industrial and commercial machinery and computer equipment	18
36	Electronics and other electrical equipment and components	13
37	Transportation equipment	12
38	Measuring, analyzing, and controlling instruments	2
39	Miscellaneous manufacturing industries	4
40	Railroad transportation	1
42	Motor freight transportation and warehousing	1
49	Electric, gas, and sanitary services	3
50	Wholesale trade-durable goods	2
51	Wholesale trade-nondurable goods	2
73	Business services	1
75	Automotive repair, services, and parking	1
96	Administration of economic programs	1
97	National security and international affairs	1
	Total	182

[a]Standard Industrial Classification.

Source: *Standard Industrial Classification Manual*, Executive Office of the President, Office of Management and Budget, 1987.

minimization practices are cross tabulated with variables of waste groups (and in some cases by waste streams, employment size, or selected SIC codes) to examine the set hypothesis. Waste minimization factors also are cross tabulated with variables of waste groups (and in some cases by waste streams, employment size, or selected SIC Codes) to inspect the Null Hypotheses. Throughout the statistical test evaluations, a 0.05 level of significance was selected to accept or reject the Null Hypothesis.

4.3.1 Independent Variables

In this study there were three independent variables of interest. These were quantity of waste generation, employment size, and variation in the waste streams. The data were sorted on the basis of the quantity of waste generated at three levels. Bivariate analysis between the variables was tested consecutively. Somers' d test statistic was used to study the association between variables and the direction of the association for Null Hypothesis-1 and -2.

Null Hypothesis-1: There Was No Association Between The Quantity Of Waste Generated And Employment Size.

Null Hypothesis-2: There Was No Association Between The Quantity Of Waste Generated And Waste Stream Variation.

The Null Hypothesis-1 of no association was confirmed between the quantity of waste generated and employment size by the Somers' d test ($d = 0.098$, $Z = 1.51$). Independence of employee size from waste generation was somewhat unexpected. One would expect higher employment levels at those plants producing more waste.

There was, statistically, a highly significant association (dependency) between the variables of quantity of waste generated and waste streams ($d = 0.184$, $Z = 2.92$, $p < 0.05$). The Null Hypothesis-2 here was rejected in favor of an alternative hypothesis of association. Somers' d, with a plus sign, provides us with a positive correlation between these two variables. This indicates that an increase in the quantity of waste generated was associated with an increase in waste streams. The dependency between these two variables was expected.

In statistical evaluations of waste minimization practices and waste minimization factors, variation by quantity of waste will be investigated. However, since there was a strong correlation between the quantity of waste generated and variation in waste streams, conclusions drawn from one variable can apply to the other as well.

4.3.2 Waste Minimization Practices and the Quantity of Waste Generation

Adoption of waste minimization practices was measured through nine statements. These statements were constructed to measure respondent activities in different areas (though these areas are not necessarily judged of equivalent value). Statistical analysis was carried out on all nine practices as a group to convey an overall picture, as well as individually on each practice.

The nine waste minimization practices were set forth in questions 6 to 14 on the survey form (Appendix B, Survey Form). Respondents provided answers according to a scale of five implementation levels: 5 = implemented with quantifiable results, 4 = began implementation or planning to begin soon, 3 = evaluated, determined not to implement, 2 = evaluating, and 1 = not evaluated or not applicable.

Samples were categorized on the basis of the variation in waste quantity generated. Table 4.7 describes the distribution of generators' responses to the waste minimization practices by these three categories. Mean and median values for the adoption of waste minimization practices decreased as one moved from the larger to the smaller waste generators. The dispersion of the three samples (see standard deviation) increased as waste quantity decreased. For Group One, 50% of the scores were at 29.0 ± 3.5, and 68% of the scores at 28.8 ± 6.4 for Group Two, 50% of the scores were at 28.0 ± 5.5 and 68% of the scores were at 27.8 ± 7.0. For Group Three, 50% of the scores were at 26.0 ± 5.0 and 68% of the scores at 25.6 ± 7.3. As can be seen, the three groups had similar distributions.

Null Hypotheses-3 to -6 were postulated to study if independent samples by variation in waste quantity, waste streams, employment size, and selected SIC codes were from the same populations for responses to waste minimization practices.

Table 4.7. Distribution of scores for waste minimization practices by waste quantity categories

Values	Waste quantity categories		
	Group 1[a]	Group 2[b]	Group 3[c]
N	42.0	49.0	87.0
Mean	28.8	27.8	25.6
Standard deviation	6.4	7.0	7.3
Range	30.0	29.0	30.0
Median	29.0	28.0	26.0
Mode	29.0	28.0	29.0
Semi-interquartile range	3.5	5.5	5.0
Skewness	0.3	−0.2	−0.1

[a]Facilities producing more than 10^6 kg per year.

[b]Facilities producing $10^5 - 10^6$ kg per year.

[c]Facilities producing $10^3 - 10^5$ kg per year.

Null Hypothesis-3: There Were No Differences In Implementation Levels Of Waste Minimization Practices Among The Tennessee Waste Generators As Categorized On The Basis Of Waste Quantity Generation.

Null Hypothesis-4: There Were No Differences In Implementation Levels Of Waste Minimization Practices Among The Tennessee Waste Generators As Categorized On The Basis Of Waste Stream Variability.

Null Hypothesis-5: There Were No Differences In Implementation Levels Of Waste Minimization Practices Among The Tennessee Waste Generators As Categorized On The Basis Of Employment Size.

Null Hypothesis-6: There Were No Differences In Implementation Levels Of Waste Minimization Practices Among The Tennessee Waste Generators As Categorized On The Basis Of Major SIC Codes.

To test for Null Hypotheses-3 to -6, the data were statistically treated for the Kruskal-Wallis One-Way Analysis of Variance based on responses from nine statements (Table 4.8). The Kruskal-Wallis test provided a test for inferences concerning the location of central tendency for the three groups.

A Kruskal-Wallis Analysis of Variance test for Null Hypothesis-3 did not indicate a significant effect for the three groups of different quantity waste generators ($X^2 = 5.49$, df = 2). A value required for a significance at $\alpha = 0.05$ is 5.99. This implied that the three group samples and their corresponding populations have similar distribution functions.

A study of the association between waste quantity and waste stream variability provided a positive dependency in the previous section (Null Hypothesis-2). The three groups, separated according to the variation in their waste streams, were also tested for association with waste minimization practices using the Kruskal-Wallis test. This test also did not indicate a significant difference in waste minimization practices ($X^2 = 4.53$, df = 2).

By the Kruskal-Wallis test, response scores of Tennessee waste generators on the waste minimization practices were tested by three employment categories to make inferences for corresponding populations. Null Hypothesis-5 was rejected for this test since the Kruskal-Wallis test indicated a significant effect at 0.05 level of significance ($X^2 = 7.55$, df = 2, $p < 0.05$).

Table 4.8. Kruskal-Wallis test results for waste minimization practices by independent samples

Kruskal-Wallis X^2 values	Waste minimization practices	Hypothesis results
By quantity waste generation	5.49	Accept Null Hypothesis df = 2
By number of waste streams	4.04	Accept Null Hypothesis df = 2
By employment size	7.55	Reject Null Hypothesis $p < 0.05$ df = 2
By major SIC[a] codes	7.35	Accept Null Hypothesis df = 3

[a]Standard Industrial Classification.

The four top waste producers with SIC codes 34, 28, 35, and 33 did not produce statistically significant results for Null Hypothesis-6 when tested by the Kruskal-Wallis Analysis of Variance ($X^2 = 7.35$, df = 3).

The Null Hypotheses-3, -4, and -6 were accepted and it was concluded that the samples and corresponding populations did not significantly differ in waste minimization practices when they have different amounts of waste, waste streams, or are involved in a different industry. However, the Null Hypothesis-5 was rejected. It was determined overall that generators with different quantity waste, waste streams, or SIC codes replied to the questions similarly, but differed in their replies depending on the employment size of their companies.

The answers from each group were examined using Kendall's Coefficient of Concordance to identify those practices that were implemented at the highest and lowest levels. Null Hypothesis-7 was tested to identify these areas.

Null Hypothesis-7: There Was No Agreement Among The Three Groups Of Tennessee Waste Generators As Categorized On The Basis Of Waste Quantities And The Implementation Level Of Waste Minimization Practices.

Table 4.9 illustrates how the three groups of different quantity waste generators ranked nine waste minimization practices. These rankings were determined by assigning values to the mean scores obtained from each group for each practice. Kendall's Coefficient of Concordance ($W = 0.95$) indicated strong agreement among the three groups in their responses to waste minimization practices. The Null Hypothesis-7 of no agreement was rejected ($X^2 = 22.76$, $p < 0.05$, df = 8), indicating significant agreement among the three groups. This test also indicated that group differences, by waste quantity, did not lead to different waste minimization activity levels.

Practice 7 (improvements in housekeeping) received the highest ranking nearly unanimously. This was followed by practice 8 (improvements in awareness), practice 6 (changes in process equipment or technology), and practice 12 (off-site recycling operations). The lowest ranking was obtained for practice 10 (changes in the final products). This indicated that facilities have not wanted to make changes related to product changes. Two other practices 13 and 14 (off-site treatment and on-site treatment) were also ranked low.

Table 4.9. Ranking of waste minimization practices among waste generators of varying waste amount[a]

Waste minimization practices	Rank by sample			Sum of rank total
	Group 1[b] $N_1 = 42$	Group 2[c] $N_2 = 49$	Group 3[d] $N_3 = 87$	N = 178
6. Changes in process equipment or technology	8	7	7	22
7. Improvements in "housekeeping" or general operations	9	9	9	27
8. Improvements in employee awareness of waste minimization practices	7	8	8	23
9. Changes in raw materials used in operations	3	5	6	14
10. Changes in the final products produced	1	1	1	3
11. On-site recycle operations	4	4	5	13
12. Off-site recycling operations	6	6	4	16
13. On-site treatment for volume and/or toxicity reduction	5	3	2	10
14. Off-site treatment for volume and/or toxicity reduction	2	3	3	7
				135

[a]Kendall's test results: $W = 0.95$, $X^2 = 22.76$, $P < 0.05$, df = 8.

[b]Facilities producing more than 10^6 kg per year.

[c]Facilities producing 10^5 to 10^6 kg per year

[d]Facilities producing 10^3 to 10^5 kg per year.

Since test results using the Kruskal-Wallis test showed substantial agreement between the waste quantity variable and the waste stream variable, Kendall's Coefficient of Concordance was not tested again for the variation by waste stream.

Waste minimization practices were also investigated individually. Waste practice rankings according to the five levels of implementation were statistically tested among the three group of different quantity waste generators. The intent was to determine the statistical relationship of the two variables as well as the direction of this relationship.

Null Hypothesis-8: There Was No Correlation Between The Different Quantity Waste Generators And Different Levels Of Waste Minimization Practice.

Three-by-five contingency tables were constructed and Somers' d statistic was used for testing these measurements. The contingency tables showed three categories of waste generators by increasing levels of waste production (independent variable) and five levels of waste minimization implementation, ranging from one to five (Appendix B, Survey Form). Table 4.10 has the Somers' d values for practices 6 to 14. The column/row (C/R) values from the computer printout provided Somers' d values. C/R denoted that the row variable was regarded as an independent variable and the column variable as a dependent variable. Somers' d used a correction only for pairs that were tied to the independent variable. Practice 6 (changes in the process equipment) and practice 13 (on-site treatment) exhibited statistical significance ($d = 0.180$, $Z = 2.81$, $p < 0.05$ and $d = 0.336$, $Z = 5.42$, $p < 0.05$, respectively) and for these two practices, the Null Hypothesis-8 of no association was rejected. This meant that for these two waste minimization practices there was a positive association between rankings on waste minimization activity level and the amount of waste generated. Namely, the bigger waste generators had a higher level of activity in these areas. Furthermore, the change in waste production caused or predicted these survey answers. The other waste minimization practice areas did not exhibit statistical association by change in waste production and for them, the Null Hypothesis-8 of no association was accepted.

Table 4.10. Association of variables by Somers' d statistics for waste minimization practices and quantity of waste generation

Waste minimization practices	Somers' d values	Z values	Null hypothesis results
6. Changes in process equipment or technology	0.180	2.81	Rejected, $p < 0.05$
7. Improvements in "house-keeping" or general operations	0.024	0.36	Accepted
8. Improvements in employee awareness of waste minimization practices	-0.009	-0.130	Accepted
9. Changes in raw materials used in operations	0.049	0.73	Accepted
10. Changes in the final products produced	-0.013	-0.22	Accepted
11. On-site recycling operations	0.088	1.19	Accepted
12. Off-site recycling operations	0.119	1.80	Accepted
13. On-site treatment for volume and/or toxicity reduction	0.336	5.42	Rejected, $p < 0.05$
14. Off-site treatment for volume and/or toxicity reduction	0.023	0.35	Accepted

As indicated by Kendall's Coefficient of Concordance tests, there was very strong overall agreement among the three groups categorized by quantity of waste. There were no group differences, which meant that all groups were at the same level of activity in adopting waste practices. As a result, the three group scores were combined and levels of each waste generation practice were analyzed. Figure 4.3 provides the levels of waste practice implementation.

Three practices were listed as "not evaluated/not applicable" in over 45% of the responses. These were, practice 10 (changes in the final products), 13 (on-site treatment), and 14 (off-site treatment). Over seventy percent (71.1%) of the respondents chose the level of "not evaluated/not applicable" for practice 10. These practices were viewed as least applicable by the Tennessee generators. Another 32 to 36% of respondents marked practice 9 (changes in raw materials), practice 11 (on-site recycling), and practice 12 (off-site recycling) as "not evaluated/not applicable."

Scores were low in the "evaluating" category. The highest scores were in practice 9 (changes in raw materials), practice 11 (on-site recycling), and practice 13 (on-site treatment) 15.4%, 19.8%, 14.9%, respectively.

At the "evaluated and determined not to implement" level, responses ranged from 2.2% to 14.3%. Practice 11 (on-site recycling) was the practice gathering the highest score for this response.

At the "began implementation or planning to begin soon" level, responses were fewer than 12%, except for practices: 7 (improvements in housekeeping) and 8 (improvements in awareness). In these areas responses ranged from 26% to 27.1%.

And, finally, the level "implemented with quantifiable results" was chosen by over 45% of the respondents for practices: 6 (changes in process), 7 (improvements in housekeeping), 8 (improvements in awareness), and 12 (off-site recycling). Other waste minimization practices garnered this response in 9.3% to 30.8% of the cases. When "implemented" and "initiated" levels were combined, we found a response rate ranging from 51 to 82% for the practices 6, 7, 8, and 12. This indicated a considerable amount of implementation over the past two years,

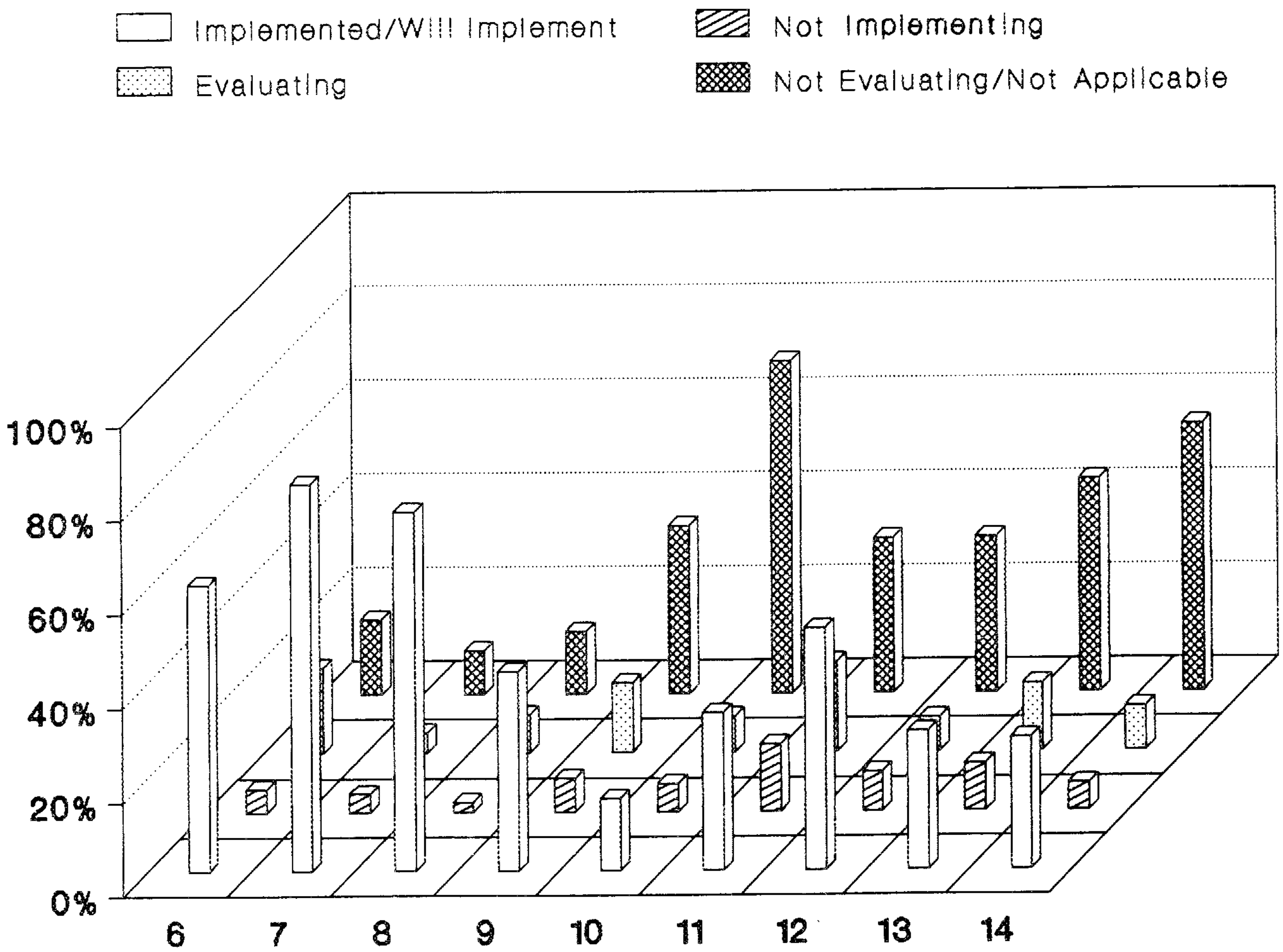

Fig. 4.3. Waste minimization practices by varying implementation levels.

[a]Questions 6 to 14 match survey form questions .

though the effect on volume reduction cannot be determined through this measure. The practice 10 (changes in the final products) was the lowest implemented practice at this level of implementation (9.3%).

Levels of waste reduction were very roughly ascertained through question 15. Typically, all three waste generation groups judged their waste minimization programs as producing "moderate" results (overall 62.5%). Null Hypothesis-9 was stated to study the relationship between levels of waste minimization (as extensive, moderate, negligible) and different quantities of waste generation.

Null Hypothesis-9: There Was No Correlation Between Different Quantity Waste Generators And Their Judgement As To The Extent Of Waste Minimization Practice Levels 4 and 5.

A positive correlation was determined between two variates ($d = 0.15$, $Z = 2.5$, $p < 0.05$) of judgment on the waste minimization level and differing waste quantity. This meant that the larger waste generators evaluated their waste minimization practices as more extensive than smaller generators. Waste minimization practices at levels 4 and 5, classified according to the three groups of waste producers, are illustrated in Fig. 4.4.

4.3.3 Waste Minimization Factors (Regulations, Economics, Environment, and Technology) and Quantity of Waste Generation

In the survey, groups of statements covering four distinct waste minimization factors were evaluated by the respondents using the scale of: 5 = strongly agree, 4 = agree, 3 = undecided, 2 = disagree, and 1 = strongly disagree.

The statistical tests to measure respondent perceptions on the four waste minimization factors made use of the following questions (Appendix B, Survey Form):

Questions 16 to 24	For regulation issues,
Questions 25 to 28	For economics issues,
Questions 31 to 36	For environmental issues, and
Questions 37 to 41	For technical know-how issues.

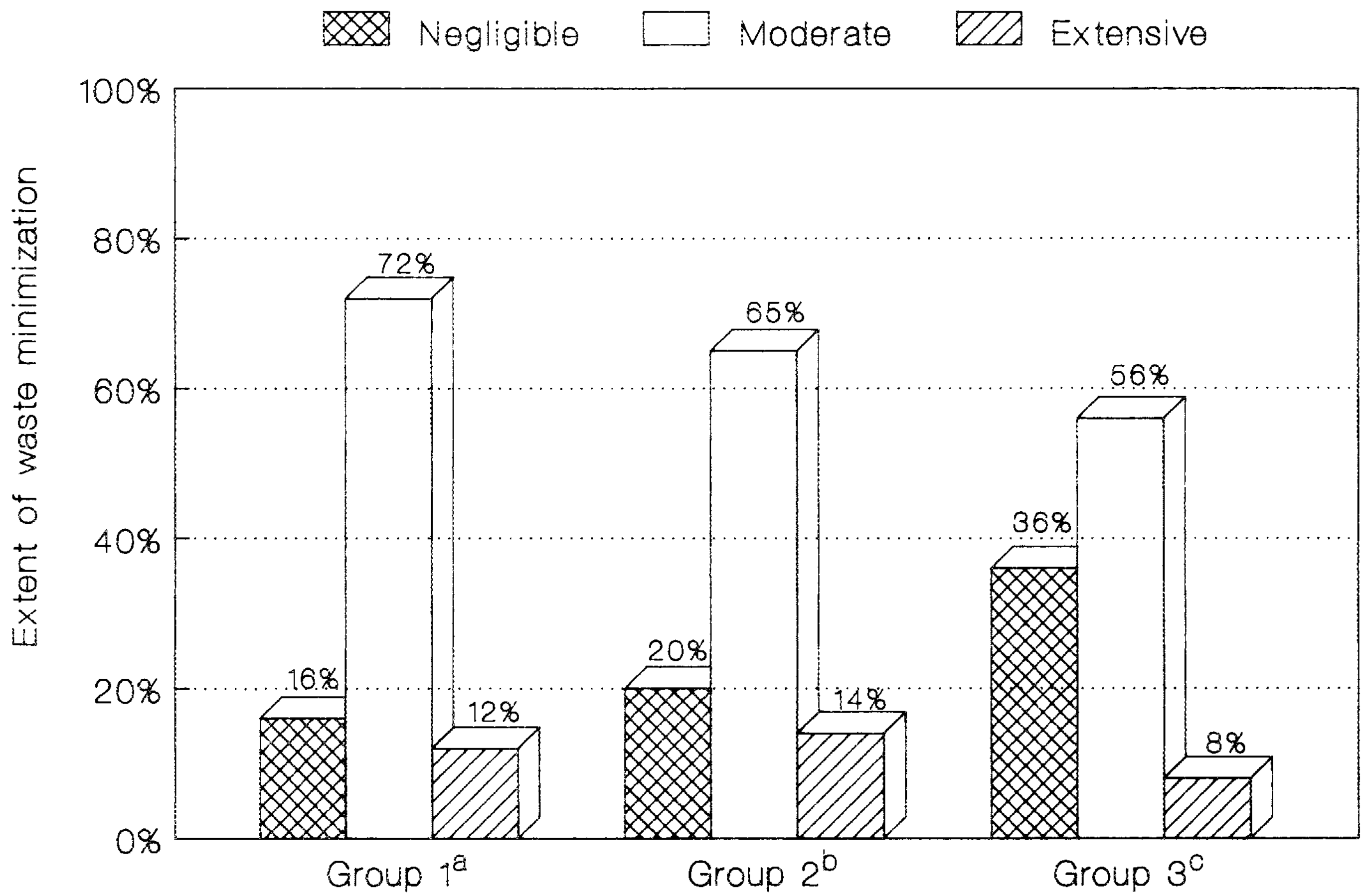

Fig. 4.4. The extent of waste minimization associated with 4 and 5 levels of implementation by the quantity of waste generation.

[a]Facilities producing more than 10^6 kg per year.
[b]Facilities producing 10^5 - 10^6 kg per year.
[c]Facilities producing 10^3 - 10^5 kg per year.

For the purposes of describing the distribution of three samples with varying quantities of waste generation, scores obtained for the four sets of waste minimization factors were computed for descriptive statistics. This information is included in Table 4.11 separately for regulations, economics, environmental concerns, and technical know-how areas.

The four selected waste minimization factor statements were statistically tested for the set Null Hypothesis with respect to various independent samples.

Null Hypothesis-10: There Were No Differences Of Opinion Among The Tennessee Waste Generators As Categorized On The Basis Of Waste Quantity Concerning The Influence Of Four Waste Minimization Factors.

Null Hypothesis-11: There Were No Differences Of Opinion Among The Tennessee Waste Generators As Categorized On The Basis Of Waste Stream Variability Concerning The Influence Of Four Waste Minimization Factors.

Null Hypothesis-12: There Were No Differences Of Opinion Among The Tennessee Waste Generators As Categorized On The Basis Of Employment Size Concerning The Influence Of Four Waste Minimization Factors.

Null Hypothesis-13: There Were No Differences Of Opinion Among The Tennessee Waste Generators As Categorized On The Basis Of Major SIC Codes Concerning The Influence Of Four Waste Minimization Factors.

The independence of the groups of generators was tested by the Kruskal-Wallis test for each one of the four factors. The results of the tests for the four factors by different independent samples are summed in Table 4.12 and indicate no significance at the 0.05 level of significance. Hence, the Null Hypotheses-10 to -13 were accepted. It was also accepted that the populations corresponding to groups of samples (either on the basis of the quantity of waste, varying waste streams, employment size, or different SIC codes) must have similar distributions. This implied that the groups responded to the waste minimization factors very similarly.

Null Hypotheses-14 to -17 were tested by Kendall's Coefficient of Concordance to examine the correlation among k samples and to identify high and low ranking questions.

Table 4.11. Distribution of scores for the four waste minimization factors by waste quantity categories

Waste minimization factors	Waste quantity categories		
	Group 1[a]	Group 2[b]	Group 3[c]
Regulations			
N	41.0	46.0	86.0
Mean	31.4	30.4	29.9
Standard deviation	5.7	6.3	7.1
Range	24.0	27.0	32.0
Median	33.0	31.0	31.0
Mode	33.0	36.0	32.0
Semi-interquartile range	3.0	4.0	5.0
Skewness	−1.3	−0.4	−0.3
Economics			
N	43.0	50.0	89.0
Mean	14.8	15.1	15.1
Standard deviation	2.2	2.6	2.4
Range	11.0	11.0	12.0
Median	14.0	16.0	15.0
Mode	14.0	16.0	16.0
Semi-interquartile range	1.5	1.5	1.0
Skewness	0.2	−0.9	−0.4
Environmental concerns			
N	42.0	50.0	87.0
Mean	23.3	22.8	22.3
Standard deviation	3.1	2.8	2.7
Range	15.0	12.0	15.0
Median	24.0	23.0	22.0
Mode	24.0	24.0	22.0
Semi-interquartile range	1.0	2.0	1.5
Skewness	−0.4	0.1	−0.3
Technical know-how			
N	42.0	50.0	87.0
Mean	16.4	16.3	16.5
Standard deviation	2.1	2.6	3.5
Range	9.0	11.0	15.0
Median	16.0	16.5	17.0
Mode	16.0	18.0	19.0
Semi-interquartile range	1.5	1.5	2.5
Skewness	0.0	−0.5	0.1

[a]Facilities producing more than 10^6 kg per year.

[b]Facilities producing $10^5 - 10^6$ kg per year.

[c]Facilities producing $10^3 - 10^5$ kg per year.

Table 4.12. Kruskal-Wallis test results for waste minimization factors by independent samples

Kruskal-Wallis X^2 values	Regulations[a]	Economics[a]	Environment[a]	Technology[a]
By quantity waste generation[b]	1.77	1.80	4.24	0.23
By number of waste streams[b]	0.07	2.30	1.85	3.51
By employment size[b]	0.96	0.99	1.95	5.41
By major SIC codes[c,d]	3.62	3.73	3.16	7.63

[a]None of the results were statistically significant at $\alpha = 0.05$ level.

[b]df = 2.

[c]df = 3.

[d]Standard Industrial Classification (SIC).

Null Hypothesis-14: There Was No Agreement Among The Three Groups Of Tennessee Waste Generators As Categorized On The Basis Of Waste Quantities And Their Perception Of The Importance Of Regulatory Issues.

Null Hypothesis-15: There Was No Agreement Among The Three Groups Of Tennessee Waste Generators As Categorized On The Basis Of Waste Quantities And Their Perception Of The Importance Of Economic Issues.

Null Hypothesis-16: There Was No Agreement Among The Three Groups Of Tennessee Waste Generators As Categorized On The Basis Of Waste Quantities And Their Perception Of The Importance Of Environmental Concerns.

Null Hypothesis-17: There Was No Agreement Among The Three Groups Of Tennessee Waste Generators As Categorized On The Basis Of Waste Quantities And Their Perception Of The Importance Of Technical Know-How Statements.

The perception of the influence of regulations on waste minimization practices by different quantity waste generators were identified by testing Null Hypothesis-14. Kendall's Coefficient of Concordance was calculated to observe the association between the three groups and the factor of regulations. Mean scores obtained for each group per question were assigned ranks within groups. The rankings of regulations were presented in Table 4.13. The degree of agreement among the groups was determined to be significant statistically at a 0.05 level of significance ($W = 0.71$, $X^2 = 16.92$, $p < 0.05$, $df = 8$). Hence, the Null Hypothesis-14 of no agreement was rejected; in other words, the three groups were in agreement in ranking waste minimization regulation statements.

Highest priority was given to the statements: 19 (regulations encourage waste reduction by volume and toxicity) and 16 (regulations encourage alternative waste management for disposal). The lowest priority was given to the statements: 22 (regulations encourage audits), 23 (regulations encourage recycling of wastes), and 20 (the waste minimization certificate was important in increasing waste minimization practices).

The Kendall's Coefficient of Concordance test was applied to Null Hypothesis-15 to study the association between economic factors and the different quantity waste generators. The results of this analysis are presented in Table 4.14. There was strong agreement among the three

Table 4.13. Ranking of waste minimization factor — regulations among waste generators of varying waste amount[a]

Waste minimization factor — regulations	Rank by sample			Sum of rank total
	Group 1[b] $N_1 = 41$	Group 2[c] $N_2 = 46$	Group 3[d] $N_3 = 86$	$N = 173$
16. The Waste Minimization Regulations encourage your company to consider alternative waste management options for disposal of waste	8	8	8	24
17. Documenting waste minization in your annual report increases the significance of the Waste Minimization Regulations	4	5	3	12
18. The Waste Minimization Regulations force your company to better understand the variety of waste streams and their sources	7	4	4	15
19. The Waste Minimization Regulations encourage your company to reduce waste volume and/or toxicity	9	9	9	27
20. The Waste Minimization Regulation's certification requirement is an important factor in increasing waste minimization practice(s)	3	1	5	9
21. The Waste Minimization Regulations encourage your company to develop baseline information on the volumes and toxicity of wastes generated	6	6	6.5	18.5
22. Waste Minimization Regulations encourage your company to conduct waste audits	2	3	1	6

Table 4.13 (continued)

Waste minimization factor — regulations	Rank by sample			Sum of rank total N = 173
	Group 1[b] $N_1 = 41$	Group 2[c] $N_2 = 46$	Group 3[d] $N_3 = 86$	
23. Waste Minimization Regulations encourage your company to increase recycling of wastes	5	2	2	9
24. The land disposal restrictions of the 1984 Hazardous and Solid Waste Amendments are a major reason why waste minimization practices are being implemented	1	7	6.5	14.5
				135.0

[a]Kendall's test results: $W = 0.71$, $X^2 = 16.92$, $P < 0.05$ $df = 8$.

[b]Facilities producing more than 10^6 kg per year.

[c]Facilities producing 10^5 to 10^6 kg per year.

[d]Facilities producing 10^3 to 10^5 kg per year.

Table 4.14. Ranking of waste minimization factor-economics among waste generators of varying waste amount[a]

Waste minimization factor-economics	Rank by sample			Sum of rank total
	Group 1[b] $N_1 = 43$	Group 2[c] $N_2 = 50$	Group 3[d] $N_3 = 89$	$N = 182$
25. The rising cost of hazardous waste treatment/ disposal is a major reason why waste minimization practices are being implemented	4	3	3	10
26. Waste minimization practices are adopted to avoid potential litigation and future liability	2	2	2	6
27. Low-cost waste minimization practices should be adopted immediately	3	4	4	11
28. Management considers adopting waste minimization practices only when they are cost-effective	1	1	1	3
				30

[a]Kendall's test results: $W = 0.91$, $X^2 = 8.20$, $P < 0.05$, $df = 3$.

[b]Facilities producing more than 10^6 kg per year.

[c]Facilities producing 10^5 to 10^6 kg per year.

[d]Facilities producing 10^3 to 10^5 kg per year.

groups of waste generators (W = 0.91) for these four statements. Agreement among the three groups was statistically significant ($X^2 = 8.20$, $p < 0.05$, df = 3). The statement receiving the most significant support was 27 (low-cost practices should be adopted immediately). The lowest ranked statement was 28 (management considers adopting waste minimization practices only when they were cost effective).

The impact of environmental concerns on waste minimization practices was evaluated by reviewing respondent agreement with Questions 31 to 36.

Kendall's Coefficient of Concordance for Null Hypothesis-16 indicated a high degree of agreement (W = 0.91) among the three different quantity waste generating groups (Table 4.15). This agreement was statistically significant ($X^2 = 13.67$, $p < 0.05$, df = 3). Hence the Null Hypothesis-16 was rejected. Respondent agreement was substantial for the following: 33 (implementing waste minimization even if not cost-effective in order to enhance environmental protection) and 31 (practices can conserve raw materials). On the other hand, disagreement prevailed unanimously on Question 35 (enhancing the public image by adopting practices) and 34 (on-site waste minimization being preferred to off-site due to transportation risks.

The Null Hypothesis-17 for final waste minimization factor and technical know-how was tested.

Kendall's Coefficient of Concordance for the three groups of waste generators produced strong agreement among them (W = 0.96). This means that overall they produced similar scores. Indeed, as can be seen in Table 4.16, they had nearly identical ranking scores for all statements. The chi-square value was statistically significant ($X^2 = 11.47$, $p < 0.05$, df = 4). The highest ranks and consequently strongest agreement areas were for statements 40 (reducing the amount/toxicity of waste in new industrial processes/operations) and 41 (companies would take advantage of technical assistance offered by state or federal government). The lowest priority was given to the statement 39 (increasing the size of technical staff).

Table 4.15. Ranking of waste miminization factor-environmental concern among waste generators of varying waste amount[a]

Waste minimization factor-environmental concern	Rank by sample			Sum of rank total
	Group 1[b] $N_1 = 42$	Group 2[c] $N_2 = 50$	Group 3[d] $N_3 = 87$	N = 179
31. Waste minimization practices can conserve raw materials	6	5	6	17
32. Waste minimization practices decrease the need for hazardous waste disposal	3	4	5	12
33. Some waste minimization practices should be implemented, even if not cost-effective, in order to enhance environmental protection	4	6	4	14
34. On-site waste minimization activities are preferred to off-site waste minimization since they decrease potential transportation risks	2	2	2	6
35. Enhancing the public image of the company is an important reason for the adoption of waste minimization practices	1	1	1	3
36. The health consequences of emissions, discharges, and accidental releases to the environment are major factors in adopting waste minimization practices	5	3	3	11
				63

[a]Kendall's test results: W = 0.91, $X^2 = 13.67$, $P < 0.05$, df = 5.

[b]Facilities producing more than 10^6 kg per year.

[c]Facilities producing 10^5 to 10^6 kg per year.

[d]Facilities producing 10^3 to 10^5 kg per year.

Table 4.16. Ranking of waste miminization factor-technical know-how among waste generators of varying waste amount[a]

Waste minimization factor-technical know-how	Rank by sample			Sum of rank total
	Group 1[b] $N_1 = 42$	Group 2[c] $N_2 = 50$	Group 3[d] $N_3 = 87$	$N = 179$
37. The lack of detailed knowledge regarding waste streams and their sources prevents the adoption of waste minimization practices	2	2	3	8
38. The absence of sufficient technical know-how by the staff prevents the adoption of many waste minimization practices	3	2	2	7
39. Increasing the size of the technical staff would increase the adoption of waste minimization practices	1	1	1	3
40. Reducing the amount and/or toxicity of hazardous waste is an important element in designing new industrial processes and operations	5	5	5	15
41. Companies would take advantage of technical assistance in waste minimization practices being offered by either the state or federal governments	4	4	4	12
				45

[a]Kendall's test results: $W = 0.96$, $X^2 = 11.47$, $P < 0.05$, $df = 4$.

[b]Facilities producing more than 10^6 kg per year.

[c]Facilities producing 10^5 to 10^6 kg per year.

[d]Facilities producing 10^3 to 10^5 kg per year.

Somers' d statistic was used to test Null Hypothesis-18.

Null Hypothesis-18: There Was No Association Between Different Quantity Waste Generators And Their Evaluation Of Each Question Relating To Waste Minimization Factors — Regulations, Economics, Environmental Concerns, And Technical Know-How.

The Somers' d statistic was used to study the association predicted by Null Hypothesis-18. Three-by-five contingency tables were constructed for each waste minimization factor (see Null Hypothesis-8 for the Somers' d test). The independent variable was listed in the order of increasing waste production per year and the dependent variable consisted of five levels of agreement.

Table 4.17 provides the Somers' d values for regulation statements 16 through 24. The Null Hypothesis-18 of no association was rejected ($d = 0.151$, $Z = 2.25$, $p < 0.05$) for the statement 18 (regulations force better understanding of the variety of waste streams). Consequently, a statistically significant positive association was determined. Hence, company agreement of the influence of regulations on determining waste streams went up as the quantity of waste increased. It can also be said that the amount of waste production caused these answers.

An association of bivariates — economics and waste quantity production — was statistically tested using the Somers' d test (Table 4.18). There was a statistically significant association ($d = -0.160$, $Z = -2.35$, $p < 0.05$) of these two variates only for statement 28 (management considers adopting waste minimization practices only when they are cost-effective). This association was inversely related, which meant that as respondent quantity of waste increased, less agreement was expressed that cost was the most important issue in implementation of waste minimization practices.

The Somers' d statistic (Table 4.19) indicated a significant association of environmental factors with changes in quantity of waste production only for statement 35 (enhancing the public image by adopting practices). Consequently, as generators produced more waste, their agreement level with this statement increased. The Null Hypothesis of independence of these two variables was rejected ($d = 0.152$, $Z = 2.34$, $p < 0.05$).

Table 4.17. Association of variables by Somers' d statistics for the regulation statements and quantity of waste generation

Regulation statements	Somers' d values	Z values	Null hypothesis results
16. The Waste Minimization Regulations encourage your company to consider alternative waste management options for disposal of waste	0.044	0.71	Accepted
17. Documenting waste minimization in your annual report increases the significance of the Waste Minimization Regulations	0.104	1.55	Accepted
18. The Waste Minimization Regulations force your company to better understand the variety of waste streams and their sources	0.151	2.25	Rejected, $p < 0.05$
19. The Waste Minimization Regulations encourage your company to reduce waste volume and/or toxicity	0.041	0.63	Accepted
20. The Waste Minimization Regulations' certification requirement is an important factor in increasing waste minimization practice(s).	0.022	0.31	Accepted
21. The Waste Minimization Regulations encourage your company to develop baseline information on the volumes and toxicity of wastes generated	0.066	1.05	Accepted
22. Waste Minimization Regulations encourage your company to conduct waste audits	0.085	1.31	Accepted

Table 4.17 (continued)

Regulation statements	Somers' d values	Z values	Null hypothesis results
23. Waste Minimization Regulations encourage your company to increase recycling of wastes	0.115	1.67	Accepted
24. The land disposal restrictions of the 1984 Hazardous and Solid Waste Amendments are a major reason why waste minimization practices are being implemented	-0.126	-1.85	Accepted

Table 4.18. Association of variables by Somers' d statistics for the economics statements and quantity of waste generation

Economics statements	Somers' d values	Z values	Null hypothesis results
25. The rising cost of hazardous waste treatment/disposal is a major reason why waste minimization practices are being implemented	0.074	1.10	Accepted
26. Waste minimization practices are adopted to avoid potential litigation and future liability	−0.002	−0.03	Accepted
27. Low-cost waste minimization practices should be adopted immediately	−0.060	−0.94	Accepted
28. Management considers adopting waste minimization practices only when they are cost-effective	−0.160	−2.35	Rejected, $p < 0.05$
29. Waste minimization practices are too expensive for companies with old facilities	−0.043	−0.62	Accepted
30. Waste minimization practices are likely to increase product costs and thereby make the product less competitive in the market	−0.031	−0.44	Accepted

Table 4.19. Association of variables by Somers' d statistics for the environment concern statements and quantity of waste generation

Environmental concern statments	Somers' d values	Z values	Null hypothesis results
31. Waste minimization practices can conserve raw materials	0.031	0.52	Accepted
32. Waste minimization practices decrease the need for hazardous waste disposal	–0.005	–0.08	Accepted
33. Some waste minimization practices should be implemented, even if not cost-effective, in order to enhance environmental protection	0.084	1.42	Accepted
34. On-site waste minimization activities are preferred to off-site waste minimization since they decrease potential transportation risks	0.069	1.11	Accepted
35. Enhancing the public image of the company is an important reason for the adoption of waste minimization practices	0.152	2.34	Rejected, $p < 0.05$
36. The health consequences of emissions, discharges, and accidental releases to the environment are major factors in adopting waste minimization practices	0.034	0.55	Accepted

Somers' d statistics (Table 4.20) did not produce any statistically significant association between technical know-how scores and changes in the quantity of waste production. This indicated that larger and smaller waste generators answered questions similarly.

Fig. 4.5 illustrates the combined scores of waste generating facilities on statements concerning regulations. Respondent disagreement from levels 1 and 2 on nine statements ranged from 17.0% to 31.3%; yet the same statements received over 48.9% (48.9% to 71.4%) agreement at the 4 and 5 levels. Generators had the highest agreement with statements 16 (considering alternative waste management options), 19 (reducing waste volume/toxicity) and 21 (developing baseline information). Statements such as 23 (increase in recycling of waste) and 18 (understanding variety of waste streams) received the highest levels of disagreement (31.3% and 29.7%, respectively).

When statements on economics were tabulated with respect to the five levels of agreement, there was a clear division (Fig. 4.6). There was strong agreement (over 78%) with the following statements: 25 (rising cost of waste disposal/treatment), 26 (avoiding potential litigation and future liability), and 27 (low-cost practices being adopted). However, substantial levels of disagreement (from 42 to 59%) were raised over the following: 28 (adopting waste minimization practices only when they are cost-effective), 29 (practices being too expensive for old facilities), and 30 (increase in product costs as a result of waste minimization).

Respondent perception of the environment as a factor in waste minimization practices is outlined (by percentage) for each level of agreement (Fig. 4.7). All six statements had agreement levels of over 55% (55.5% to 85.1%). The highest disagreement (21.4%) was seen in statement 35 (enhancing public image by adopting waste minimization practices).

The scores by respondents on the agree-disagree spectrum, for technical know-how issues, are provided in Fig. 4.8. No distinct separation was seen among the first three questions, though disagreement was somewhat more prevalent than agreement. There was considerable agreement among respondents (89.5% and 71.5%) for statements 40 (reducing the

Table 4.20. Association of variables by Somers' d statistics for technology statement and quantity of waste generation

Technology statements	Somers' d values	Z values	Null hypothesis results
37. The lack of detailed knowledge regarding waste streams and their sources prevents the adoption of waste minimization practices	−0.058	−0.84	Accepted
38. The absence of sufficient technical know-how by the staff prevents the adoption of many waste minimization practices	−0.022	−0.32	Accepted
39. Increasing the size of the technical staff would increase the adoption of waste minimization practices	0.057	0.85	Accepted
40. Reducting the amount and/or toxicity of hazardous waste is an important element in designing new industrial processes and operations	0.021	0.35	Accepted
41. Companies would take advantage of technical assistance in waste minimization practices being offered by either the state or federal government	−0.036	−0.55	Accepted

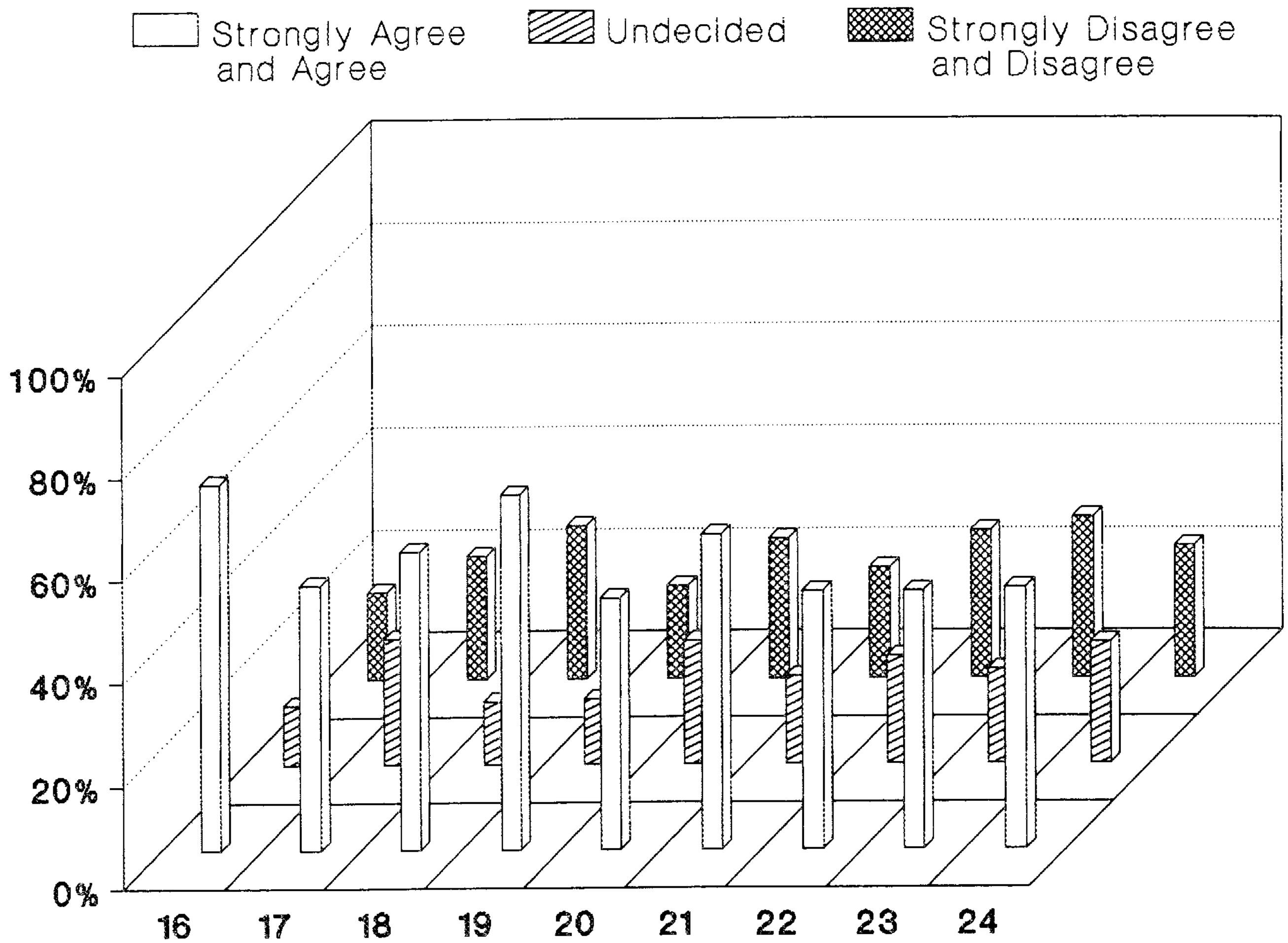

Fig. 4.5. Waste minimization factor: regulations by varying agreement levels.
[a]Questions 16 to 24 match survey form questions (Appendix E).

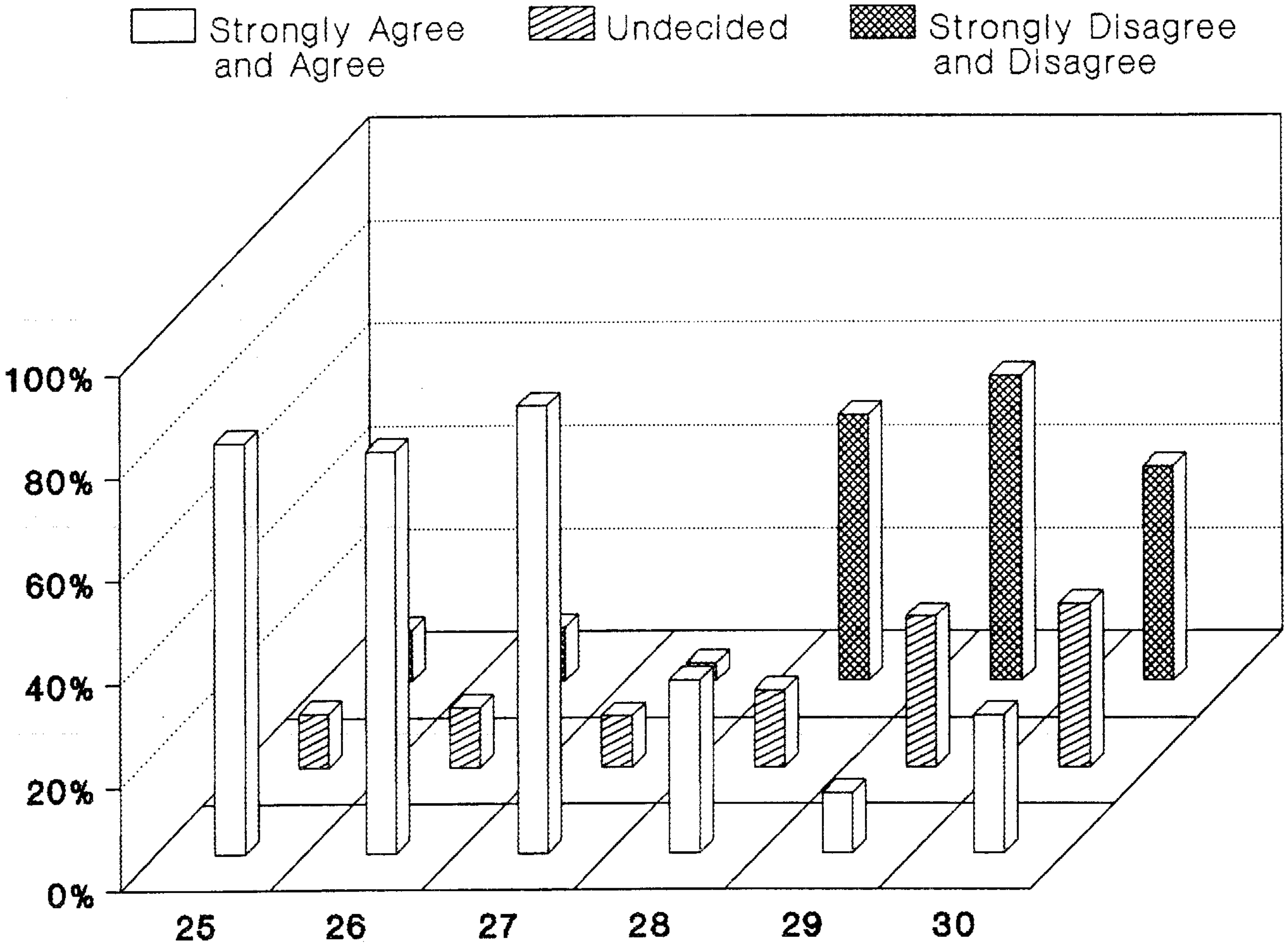

Fig. 4.6. Waste minimization factor: Economics by varying agreement levels.
[a]Questions 25 to 30 match survey form questions (Appendix E).

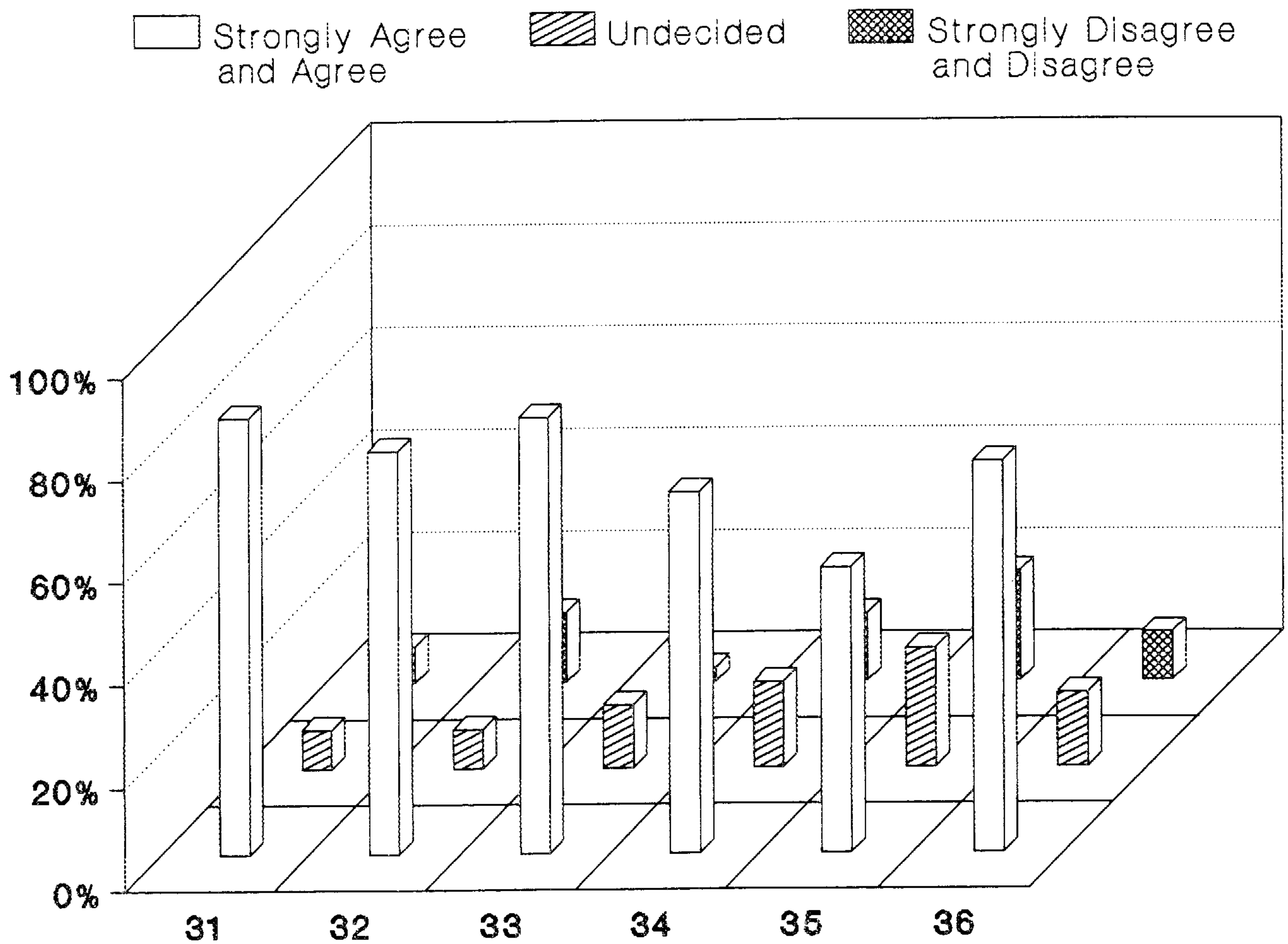

Fig. 4.7. Waste minimization factor: Environmental concerns by varying agreement levels.

[a]Questions 31 to 36 match survey form questions .

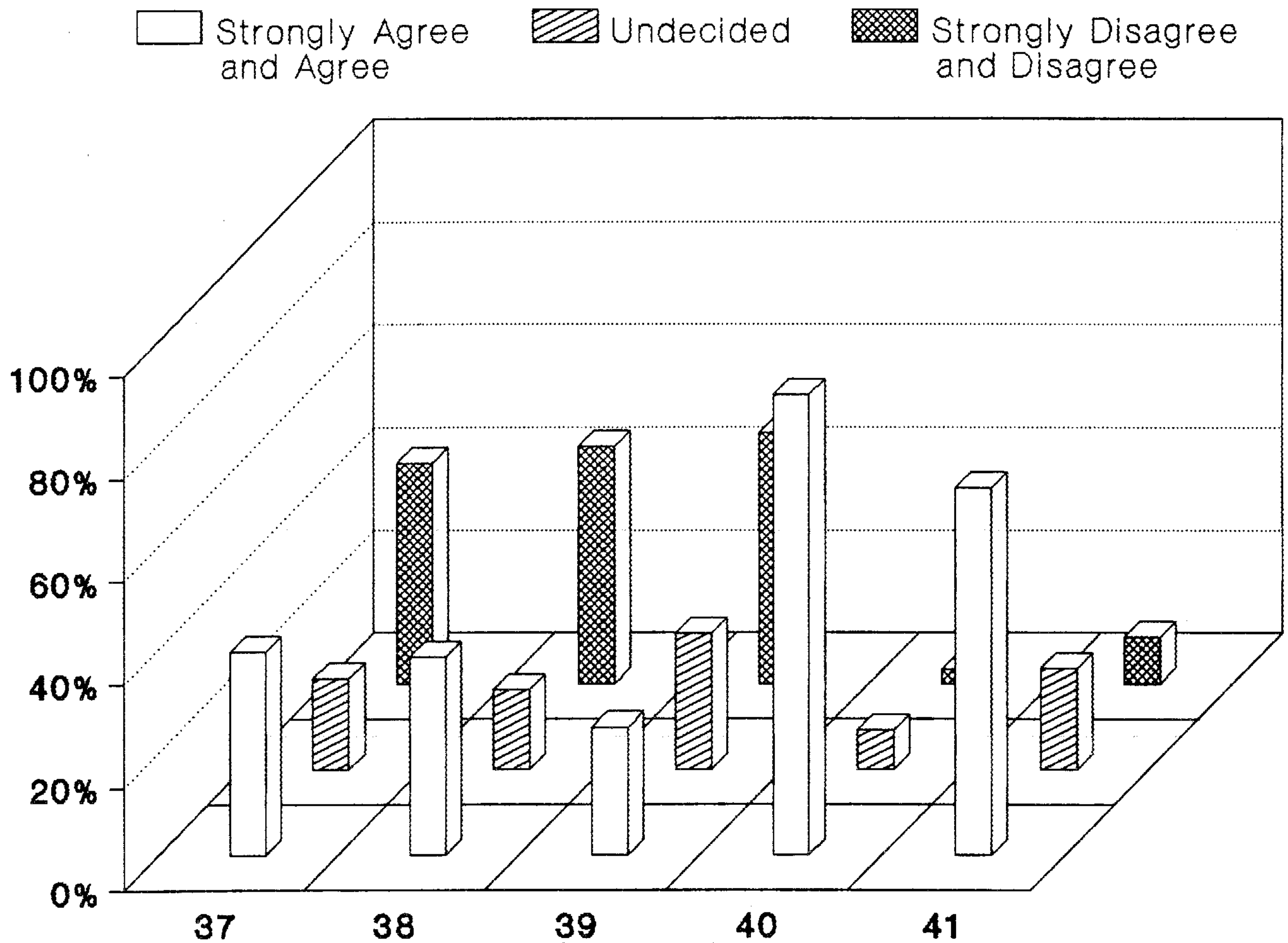

Fig. 4.8. Waste minimization factor: Technical know-how by varying agreement levels.

[a]Questions 37 to 41 match survey form questions .

amount/toxicity of waste being important in designing new operations) and 41 (companies would take advantage of technical assistance offered by the state or federal governments).

4.4 SUMMARY

The responses of Tennessee large waste generators (in Sect. 4) were examined in detail through descriptive and statistical procedures. Two general areas of interest were scrutinized: first, the nature and extent of waste minimization practices adopted by Tennessee generators since 1985; second, an examination of generator perceptions of factors (regulatory, economic, environmental and technical) that influence adoption of waste minimization practices. These varying levels of waste minimization practices and perceptions were primarily evaluated in light of three categories of waste generators (those generating different quantities of waste per year, $>10^6$ kg, $10^5 - 10^6$ kg, and $10^3 - <10^5$ kg). In addition, responses were tabulated by percentage to identify the most prominent practices among all respondents to the survey and to highlight the most influential factors.

Overall, Tennessee generators, differentiated by their quantity of waste generated, did not differ in their survey responses. On individual questions or statements there were some differences. Statistical associations for certain waste minimization practices and factors did exist.

Large Tennessee waste generators gave highest priority to three waste minimization practices: (a) improvements in housekeeping, (b) improvements in awareness, and (c) changes in process equipment or technology. Changes involving the final products were the least applicable or least desirable area for waste minimization. Off-site treatment as well as on-site treatment were also areas of low implementation.

The amount of waste generated was strongly correlated with varying waste streams. Consequently, waste stream variation can be expected to show the same relationship among variables as waste quantity variation.

Regardless of differences in quantity waste generation, respondents did not differ in their views of waste minimization factors: regulations, economics, environmental concerns, and technical know-how, although on some statements they exhibited differences.

In the following section, the researcher's findings, conclusions, and recommendations are stated as they relate to this section.

5. SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

5.1 SUMMARY

This research was undertaken for the purpose of identifying and analyzing the nature and extent of waste minimization practices undertaken by Tennessee waste generators since 1985 and of determining the importance of regulatory, economic, environmental and technical know-how factors as perceived by Tennessee waste generators.

This study had unique importance due to the timeliness of waste minimization issues. There is a great deal of interest in this area as well as a need for additional knowledge. Insight derived from this research can provide policy makers with a firm background to evaluate the status and concerns of waste generators and, consequently, to reach better decisions either through regulatory actions or public forums.

Managing hazardous waste is essential not only for establishing public policies, but also for bringing about actions that can minimize the environmental and public health effects of wastes.

There are controversial political issues related to waste disposal. As the need for landfills increases, problems with siting will affect a larger segment of the population and will provoke increasing opposition.

Waste treatment/disposal cost is a major expense for industry. Managing hazardous waste costs were between \$4.2 billion and \$5.8 billion nationwide in 1983, according to Congressional Budget Office estimates, and the cost is expected to be between \$8.4 billion and \$11.2 billion in 1990 (CBO, 1985). In addition, companies must consider possible litigation and future liability costs. These potential costs could interfere with the introduction of new products as well as increase the prices of existing products, with consequences in both domestic and foreign markets.

To address these issues, Congress in 1990 will decide the status of waste minimization regulations; that is, either to leave them in the current "voluntary" state or to create obligations forcing generators to proceed with reductions of waste. Specific industries could be singled out for additional regulations or certain regulating features within all waste generating industries could be affected. It is important for this reason that generators and their waste are characterized. It is also necessary to know what type of minimization activities are taking place under the existing regulatory status and whether increased regulation could produce additional reduction.

This study was structured to provide input into these areas of concern from the perspective of Tennessee waste generators. It was specifically directed to identify: (a) salient characteristics of companies such as employment levels, quantity of waste generation, and variation in waste streams, (b) waste minimization practices undertaken since September 1985, (c) perceptions of generators regarding selected factors influencing waste minimization practices, (d) any correlation between waste quantity generation and waste minimization practices or selected waste minimization factors, and (e) overall, the effect of the 1984 Waste Minimization Amendment.

Primary research was undertaken by conducting a mail survey of Tennessee waste generators. The survey instrument was developed (Appendix B) and validated by selected experts with experience in and understanding of hazardous waste/waste minimization issues as well as those who were experts in instrument preparation. A survey form was pretested on waste generating companies at a conference. The survey form contained five descriptive items, nine categories of waste minimization practices, nine statements on regulatory issues, six statements on economic issues, six statements involving environmental concerns, and five statements on the influence of technical know-how. The final survey form was mailed twice at three-week intervals to: (a) the entire population of Tennessee waste generators, generating more than 10^6 kg waste per year (58 generators), (b) all of those generating from 10^5 to 10^6 kg waste per year (82 generators), and (c) 50% of the randomly selected generators, generating less than 10^5 but more than 10^3 kg per year (134 generators). Of the 266 survey forms mailed (adjustments were made for those generators indicating change of status), 182 were returned, producing a 68.4% response rate.

Responses were entered into a computer file and data were classified according to the independent variable of quantity of waste generation (and in some cases by variation of waste streams, employment size, or SIC codes). Statistical tests in data analyses included: Kruskal-Wallis test, Kendall's Coefficient of Concordance, and Somers' d test. In addition, various descriptive statistics were utilized to describe different quantity waste generators in the sample as they responded to waste minimization practices and waste minimization factors. Combined sample responses were illustrated to describe each level of response. In all, hypothesis testing procedures at a 0.05 level of significance were used.

5.2 MAJOR FINDINGS

Tennessee waste generators, grouped according to different quantities of waste produced, had response rates of 74.1% (Group One), 62.5% (Group Two), and 69.5% (Group Three). Analysis of the sample revealed that 57.1% of the companies employed from 100 to 999 people. This employment category was predominant within all quantity of waste generators (over 56% for each).

Ninety-five percent of the generators sent at least some of their wastes to off-site disposal facilities.

A majority of firms, 61.5%, produced from one to three waste stream varieties. However, nearly half (48.8%) of the Group One generators produced from four to ten waste streams.

The sample covered 28 different two-digit SIC codes; however, the majority of waste producers were from the Fabricated Metal Products (22%), Chemical and Allied Products (14.3%), Machinery (10%), and Primary Metal Industries (7.7%).

Statistical findings are grouped below based on the research questions and corresponding hypotheses constructed in Sect. 1.3:

Findings 1 and 2 apply to research question 1; findings 3 and 4 apply to research question 2; findings 5 to 7 apply to question 3; finding 8 applies to question 4; findings 9 and 10 apply to question 5; findings 11 to 14 apply to question 6; findings 15 to 23 apply to question 7; and findings 24 to 26 apply to question 8.

The findings of this research are summarized as follows (see Appendix B, Survey Form for complete statements):

1. For Tennessee waste generators the changes in employment size were independent of waste quantity generation (Null Hypothesis-1).
2. There was a significant positive association between waste stream variability and waste quantity generation (Null Hypothesis-2).
3. There were no differences in waste minimization implementation levels among Tennessee waste generators as categorized on the basis of quantity of waste generated, waste stream variability, or for major waste producing industries (Null Hypotheses-3, -4, and -6).
4. There was a statistically significant difference in waste minimization implementation levels as categorized on the basis of employment size (Null Hypothesis-5).
5. There was a statistically significant agreement among the three groups of Tennessee waste generators as categorized on the basis of waste quantity, and the implementation level of waste minimization practices (Null Hypothesis-7).
6. Three waste minimization practices, 7 (improvements in housekeeping), 8 (improvements in awareness), and 6 (changes in process equipment or technology), were identified as most common practices to date.
7. Practice 10 (changes in the final products) received the lowest ranking and, consequently, was the waste minimization activity least adopted.
8. Two practices showed statistically significant positive correlations between the quantity of waste generated and different level of waste minimization implementation. These were 6 (changes in the process equipment or technology) and 13 (on-site treatment) (Null Hypothesis-8).
9. All three categories of waste generating groups (based on quantities of waste generated) judged their level of waste minimization "moderate."

10. A significant correlation existed between the size of the waste generators (based on quantities of waste produced) and the extent to which waste minimization practices have produced results; meaning the large generators judged their minimization efforts as having more of an impact than smaller generators (Null Hypothesis-9).
11. There were no differences of opinion among Tennessee waste generators concerning the influence of four waste minimization factors (regulations, economics, environmental concerns, and technical know-how) when they were categorized on the basis of quantity of waste generated (Null Hypothesis-10).
12. There were no differences of opinion among Tennessee waste generators concerning the influence of four waste minimization factors when they were categorized on the basis of waste stream variability (Null Hypothesis-11).
13. There were no differences of opinion among Tennessee waste generators concerning the influence of four waste minimization factors when they were categorized on the basis of employment size (Null Hypothesis-12).
14. There were no differences of opinion among Tennessee waste generators concerning the influence of four waste minimization factors when they were categorized on the basis of major SIC codes (Null Hypothesis-13).
15. There was a statistically significant agreement among the three groups of Tennessee waste generators as categorized on the basis of waste quantity and their perception of the importance of waste minimization factors (Null Hypotheses-14, -15, -16, and -17).
16. Respondent agreement was particularly seen in regulation statements 19 (regulations encourage waste reduction by volume and toxicity) and 16 (regulations encourage alternative waste management options for disposal).
17. Lowest priority was given to the regulation statements, 22 (regulations encourage audits), 23 (regulations encourage recycling), and 20 (waste minimization certificate is important in increasing waste minimization).

18. Economic factors were seen as particularly important in the statements 27 (low-cost practices should be adopted immediately) and 25 (rising cost of waste treatment/disposal is a major reason for waste minimization).
19. Lowest importance in economics was given to statement 28 (management considers adopting waste minimization practices only when they are cost-effective).
20. The highest ranking covering environmental concerns was given for statements 33 (implementing even when practices are not cost-effective) and 31 (practices can conserve raw materials).
21. In terms of environmental factors, the least important statements were 35 (enhancing the public image by adopting practices) and 34 (on-site waste minimization being preferred to off-site due to transportation risks).
22. For technical know-how, the highest rankings were accorded the statements 40 (reducing the amount/toxicity of waste in new industrial processes/operations) and 41 (companies would take advantage of technical assistance offered by state or federal government).
23. The lowest priority for technical know-how was given to 39 (increasing the size of technical staff).
24. There was statistically positive and significant association between agreement with statement 18 (regulations force companies to better understand the variety of waste streams) and increasing waste generation (Null Hypothesis-18).
25. There was a statistically significant and negative association between agreement with statement 28 (management considers adopting waste minimization practices only when they are cost-effective) and increasing waste generation (Null Hypothesis-18).
26. There was a statistically significant and positive association between agreement with statement 35 (enhancing the public image by adopting practices) and increasing waste generation (Null Hypothesis-18).

The following waste minimization practices were notable at the successive levels of waste minimization for combined samples:

1. Practices 10 (changes in the final product), 13 (on-site treatment), and 14 (off-site treatment) were frequently (by 45-71% for each practice) reported as "not evaluated/not applicable."
2. The "evaluating" category was marked by relatively few respondents. Only 15 to 20% activity in this category was reported for practices 9 (changes in raw materials), 11 (on-site recycling), and 13 (on-site treatment).
3. Respondents did not demonstrate much activity (2-14%) for practices in the category "evaluated, but determined not to implement."
4. Three to twenty-seven percent activity was reported in the "began implementation or planning to begin soon" category. Practices 7 (improvements in housekeeping) and 8 (improvements in awareness) received the highest (26 and 27%, respectively) activity.
5. Over 45% of the respondents chose "implemented with quantifiable results" for practices 6 (changes in process equipment or technology), 7 (improvements in housekeeping), 8 (improvements in awareness), and 12 (off-site recycling).
6. Two levels of waste minimization practices "implemented with quantifiable results" and "began implementation or planning to begin soon" combined, produced over 50% activity for practices 6 (changes in process equipment or technology), 7 (improvements in housekeeping), 8 (improvements in awareness), and 12 (off-site recycling).

Respondents favored the following statements in the regulatory, economic, environmental, and technical categories for combined samples:

1. Over 50% of the respondents chose "agree" and "strongly agree" categories for each one of the regulatory statements. The highest were 71 and 69% for statements 16 (regulations encourage alternative waste management options for disposal) and 19 (regulations encourage waste reduction by volume and toxicity).

2. Seventy-eight to ninety-seven percent agreement was reported in "strongly agree" and "agree" categories for economic statements 25 (the rising cost of waste treatment/disposal is a major reason for waste minimization), 26 (waste minimization practices are adopted to avoid potential litigation and future liability), and 27 (low-cost practices should be adopted immediately). Fifty-nine percent of the respondents disagreed with statement 29 (waste minimization practices are too expensive for companies with old facilities).
3. All environmental statements received over a 55% score for the "strongly agree" and "agree" categories.
4. For technical know-how statements, respondents definitely agreed (71% and 90%) with statements 40 (reducing the amount/toxicity of waste in new industrial process/operations) and 41 (companies would take advantage of technical assistance offered by state or federal governments), respectively; however, they disagreed (over 43% each) with statements 37 (the lack of detailed knowledge regarding waste streams and their sources prevents the adoption of waste minimization), 38 (the absence of sufficient technical know-how by the staff prevents the adoption of many waste minimization practices), and 39 (increasing the size of technical staff).

5.3 CONCLUSIONS

The survey conducted to research hazardous waste minimization strategies of Tennessee generators produced findings stated in the previous section. On the basis of these findings, a number of conclusions were reached. These conclusions are stated below.

1. The quantity of waste generated by Tennessee waste generators was independent of employment size but dependent on waste stream variability.
2. Hazardous waste minimization practice levels of companies did not differ significantly according to company differences in waste quantity, waste stream variability, or major SIC codes; they did differ significantly by employment size.

3. Differing quantity waste generators had similar waste minimization practices. They consistently implemented some practices but not others.
4. Tennessee waste generators showed some variation in selected practices on the basis of different waste production.
5. Most Tennessee waste generators felt their waste minimization practices had achieved "moderate" results to date in reducing overall waste levels and larger waste generators evaluated their waste minimization practices as being more extensive than smaller generators.
6. Tennessee waste generators did not differ significantly in their views of waste minimization factors: regulations, economics, environmental concerns, and technical know-how regardless of differences in waste quantity generation, waste stream variability, employment size, or major SIC codes.
7. Differing quantity waste generators had similar perceptions of important waste minimization factors. Certain statements in particular drew a favorable response.
8. There was some association between increasing amounts of waste production and agreement on certain selected statements related to waste minimization factors.

5.4 RECOMMENDATIONS

Based on this research the following recommendations are presented:

1. Tennessee hazardous waste generators should not be differentiated or put into subgroups on the basis of the quantity of waste generated, waste stream variability, or different industries.
2. It is recommended that annual reports include specific waste minimization categories as differentiated in the survey form used in this research. In addition, the level of activity should also be obtained from the generators in a uniform format.
3. States or EPA should explore methods to promote waste minimization practices that generators neither clearly favored nor disfavored, such as changes in raw materials and on-site recycling operations.

4. State and federal technical assistance should be provided to generators (71.5% agreed with statement 41). This would be a very positive step forward, as it would not only increase waste minimization but would create a partnership between industry and government. As a first step, technical state assistance programs (such as those in North Carolina and Minnesota) should be studied.
5. Existing regulations should be reviewed and possible changes should be made to encourage the recycling of wastes and the conduct of audits.
6. It is recommended that when this research is repeated by researchers in other states, employment size should be studied in more detail. The survey form could contain an open-ended question to give the respondent and the researcher the flexibility to go beyond fixed categories.
7. It is recommended that small generators be included in subsequent surveys, because they are now covered by waste minimization regulations.

6. THE STUDY IN RETROSPECT

A survey of "Hazardous Waste Minimization Practices in Tennessee" was conducted for the purpose of identifying and evaluating the waste minimization practices of Tennessee waste generators and of determining the importance of waste minimization factors since September 1985. Designing a survey form incorporating distinct waste minimization categories, a generic scale of measurement, and several statements on the factors affecting waste minimization, accomplished a considerable part of this purpose. The categories and scales constructed in the survey instrument, if felt desirable, can be adopted by the state and federal governments to gather similar data from generators outside Tennessee. Presently, generators report their waste minimization activities in an unspecified format, which makes it very difficult to standardize and evaluate efforts uniformly. A standard would provide a common framework and organization for waste minimization information. If key information areas were identified by the state/EPA, then it is recommended that an approved recordkeeping structure be kept by the companies so that current data are available to prepare annual reports or to provide meaningful answers to audits.

Overall, Tennessee waste generators were quite willing (68.4% return rate) to participate in the survey and to make known their activity areas and opinions on the subject (Appendix F). Special effort was made not to attempt to obtain potentially sensitive information. For example, in this survey most generators did not identify in the questionnaire the specific waste streams they produced. Obviously, even in a generic form, this was considered proprietary information. Information must be obtained from generators in a nonthreatening way.

As seen from this survey, Tennessee generators are fairly united in their views and preferences. In general, they have a positive attitude toward waste minimization. They generally disagreed with the statement that waste minimization practices were likely to increase product costs and lead to problems with market competitiveness.

Consequently, the generators have begun to implement, or have fully implemented, various waste minimization practices; especially

(a) improvements in housekeeping, (b) improvements in awareness, and (c) changes in process equipment or technology. Though they claim these efforts have produced just "moderate" results to date, they indicate no apathy or indifference. Tennessee respondents felt that while cost was an important issue in taking action, it was by no means the sole reason for action and they did not feel that old facilities should be excluded from consideration for action.

The highlight of this research was the understanding that Tennessee waste generators did not differ in adopting waste practices regardless of differences. Grouping waste generators by the quantity of waste production has been an accepted practice by RCRA regulations. In 1980, EPA separated large waste generators (generating waste more than 1,000 kg per month) from small (generating waste less than 1,000 kg per month) for regulatory purposes. By 1984, however, even those generating from 100 to 1,000 kg per month came under RCRA regulations. This study has shown that among those generators having over 1,000 kg per month of waste, variation by quantity of waste generation was not an important distinction for waste minimization. Inclusion of even smaller waste generators (generating only one million tons per year) will not make much difference in reducing waste amounts regardless of the practices adopted. However, it would be interesting to study their practices.

Consequently, instead of regulating by various size groupings, emphasis should be placed on process and technical waste minimization methods. Generators accepted the idea of waste minimization and want to make modest investments in waste minimization even if these were not cost-effective. Generators need some direction and technical help, however.

Regardless of the quantity of waste generated, waste stream variability, employment size, or SIC code, generators were in essential agreement on the regulatory, economic, environmental, and technical issues influencing waste minimization. Therefore, there was a very common perspective evident.

The greatest strength of this study was to demonstrate the common practices and views of Tennessee waste generators. Their common problems and approaches to these problems were much more important than their differing attributes.

The somewhat surprising finding was the cost factor. Cost was often given as a major reason for adopting waste minimization practices, therefore, it was revealing to find that: (a) 51.7% of the respondents disagreed that "management considers waste minimization practices only when they are cost-effective" and (b) 85% of the respondents agreed that "some waste minimization practices should be implemented, even if these were not cost-effective, to enhance environmental protection."

We need not wait until 1990 to resolve some of the outstanding concerns that still exist (the date EPA selected rather arbitrarily to report back to Congress on the need for mandatory waste minimization regulations). However, this does not mean it is appropriate to set obligatory quantitative reduction standards now or to establish a system for accountability of hazardous materials in mass balance. It is premature to impose these types of obligations and probably counterproductive as well. This research has shown that "voluntary" regulations are producing results. Furthermore, no one has yet demonstrated how EPA can set uniform and enforceable standards across different industries to produce significant and equitable results. This study has also shown that it makes no sense to segregate large generators for regulatory purposes simply because the level and composition of their activity is so similar.

The answers to today's problems, therefore, are not found through more restrictive regulation. Companies in this study agreed that the existing regulations are forcing them to do more in terms of waste minimization. Rather the time has come to resolve important methodological concerns and issues and to set in place a government framework for future assistance and regulations.

The major methodological issues of interest to regulators, industry, and environmental groups now being debated have been reported in two Office of Technology Assessment reports, Serious Reduction of Hazardous Waste and From Pollution to Prevention, and in EPA's five volume effort Reports to Congress on the Minimization of Hazardous Waste.

OTA and EPA dispute the extent to which waste minimization is already taking place and whether much more action can be taken by industry. How can this dispute be resolved when basically we are forming our assumptions on selected cases and we have not universally defined what constitutes waste minimization or the proper unit of comparison?

EPA, through its 1984 requirements (a) added certification requirements on waste manifests, (b) required the reporting of waste minimization activities in biennial reports, and (c) administered certification requirements in new permits issued for treatment, storage, or disposal of hazardous waste. These added burdens need to be carefully evaluated before 1990. First, terms such as "waste minimization," "waste reduction," and "source reduction" are not always used interchangeably, and their precise meanings have to be clarified. Consequently, what to report in the biennial report, and in what format, is not clear. What "wastes" will be included in waste minimization is another issue. Will only RCRA wastes be included, or will wastes governed under other environmental regulations be included, or will other nonhazardous wastes, or water discharges be included? And finally, since definitions are murky, what is meant when a generator certifies a waste minimization program on the manifest is open to interpretation.

Even for a generator with the best of intentions, it is not clear if waste minimization results should be accounted for on a per production, per year, or per process basis. No guidance or common measuring stick is provided by which comparisons can be made and by which overall progress can be assessed.

Hence, before new regulatory decisions are made, the EPA needs to resolve fundamental methodological issues. It could do so by establishing a blue-ribbon panel of experts from government, industry, and environmental organizations to reach consensus on the problems that have just been identified. The decisions reached by such a panel, if sufficiently attractive to gain consensus, should then be incorporated in national legislation.

The federal government's role in establishing a uniform framework should also allow for an important state government contribution. The EPA should (a) have an ongoing dialogue with the states, (b) monitor state waste minimization programs, and (c) provide financial assistance to state programs. Once waste minimization elements are classified as noted previously, states should take the lead in implementing the waste minimization program for the EPA.

States could structure their waste minimization programs according to indigenous situations and needs. This would involve auditing and exchanging waste minimization information with other states and the EPA to stay abreast of developments. States could perhaps identify special problem areas within their jurisdictions or concentrate on special waste streams. Of course, all information gathering activities must be done in consideration of generators' operations.

State and federal governments must find the right balance between regulatory need for information and intrusive data requests. A bill now in Congress (the Lautenberg bill described in LaCroix, 1987) proposes an extensive tracking of toxic wastes generated from facility operations. It would require information on the total volume of toxic wastes generated. In addition, it would require the reporting of each waste reduction practice undertaken at a facility and the level of waste reduction actually reached. Requests for this type of information would not please generators. This type of information would entail a lot of tracking, paperwork, and would yet not be possible to gain all the information required.

Moreover, these toxic or hazardous materials are not necessarily single chemicals but mixtures. Consequently, identification of each constituent in the mixture would be costly and too specific to the firm's competitive edge to divulge. Perhaps the panel, suggested earlier, could also address the balance of information needs being discussed here.

The technical assistance role of the state is probably most important at this time in waste minimization. States and generators can mutually gain from such assistance. The exchange of ideas could assist generators, particularly in areas where generators are currently evaluating, such as (a) changes in raw materials, (b) on-site recycling, and (c) off-site recycling. Respondents strongly agreed that reducing the amount/toxicity of waste in designing new industrial processes/operations was an important factor and that companies would take advantage of technical assistance offered by state or federal governments to minimize their wastes. They, however, did not think that increasing the size of their technical staff would have much impact. Some generators commented that they would prefer to satisfy the need by using consultants rather than hiring personnel.

Information obtained from mutual efforts can be funnelled into the EPA's national data base for an overall integrative system. State involvement in a comprehensive state computer system would not only have waste data but have data bases to supply information to generators on possible waste minimization technologies, waste exchange firms, and accepted landfill firms. When such a system is established, information could be validated through quality assurance procedures.

State programs such as North Carolina's "Pollution Prevention Pays Off" and Minnesota's are successful. Presently UT Waste Management Research and Education Institute works in cooperation with the TDHE. It is highly recommended that additional channels and programs be established.

In conclusion, this study served a useful purpose in exploring the waste minimization area. It randomly sampled and studied Tennessee waste generators. It identified the high and low waste minimization activity areas in the state. It brought forward the similar practices and perceptions of Tennessee waste generators regardless of their variation by different quantity waste generation as well as those practices and perceptions that exhibited differences. Since identified waste practices are parallel to those of OTA's survey (OTA, 1986) and agree with EPA's (EPA, 1986a,b,c) and NRC's assessments of level of implementation (NRC, 1985), additional validity and reliability of this research are demonstrated. Repetition of this survey in another state would provide an opportunity for comparison.

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Appendix A

ENLISTED EXPERTS FOR REVIEW
OF SURVEY INSTRUMENT

Appendix A

ENLISTED EXPERTS FOR REVIEW OF SURVEY INSTRUMENT

A LIST OF EXPERTS FOR THE PANEL

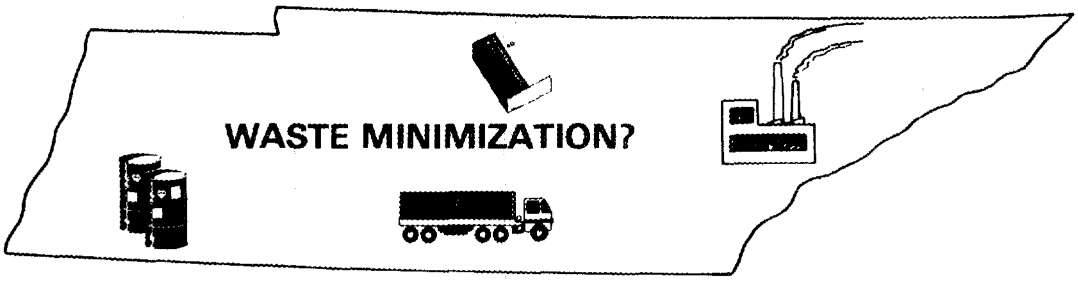
Name	Address	
Dr. E. W. Colglazier	Waste Management Research and Education Institute, The University of Tennessee Knoxville, TN 37996-0710	Director of Waste Management Institute B.S. Physics Ph.D Physics Four years experience in waste management/policy issues, five years in technology policy analysis
Mr. K. Dove	Nissan Motor Manufacturing Corp. 812 Nissan Dr. Smyrna, TN 37167	Environmental Engineer B.S. Environmental Engineering Eight years of experience in hazardous waste management
Mr. K. G. Edgemon	Martin Marietta Energy Systems, Inc. Oak Ridge National Laboratory Oak Ridge, TN 37831	Supervisor, hazardous waste operations 13 to 15 years of experience in hazardous material and waste management operational aspects
Mr. B. M. Eisenhower	Martin Marietta Energy Systems, Inc. Oak Ridge National Laboratory Oak Ridge, TN 37831	Coordinator, Hazardous and mixed waste management office B.S. Microbiology M.P.H. Public Health Ten years of experience in waste management at Oak Ridge National Laboratory and as a consultant in private industry
Dr. M. Fitzgerald	Department of Political Science The University of Tennessee Knoxville, TN 37996	Professor B.S. Political Science Ph.D. Political Science Expert in survey research with experience in hazardous waste issues and their political implications

Name	Address	
Mr. R. Graham	Tennessee Department of Health and Environment 701 Broadway Nashville, TN 37219-5403	Information Manager, Data Management Section B.S. Environmental Engineering Receiving and evaluating information for the last four years from Tennessee waste generators
Dr. T. C. Hood	Department of Sociology The University of Tennessee Oak Ridge, TN 37996-0490	Professor and Department Head B.S. Sociology Ph.D. Sociology Expert in surveys and survey instrument development
Dr. W. Lyons	Department of Political Science The University of Tennessee Knoxville, TN 37996	Professor B.S. Political Science Ph.D. Political Science Expert in survey research and political issues associated in waste management issues
Mr. S. Myers	Aluminum Co. of America Alcoa, TN 37701	Hazardous Waste Manager B.S. Environmental Engineer Experience in hazardous waste management for five years
Mr. T. H. Row	Martin Marietta Energy Systems, Inc. Oak Ridge National Laboratory Oak Ridge, TN 37831	Director of Nuclear and Chemical Waste Programs B.S. Physics M.S. Nuclear Engineering Eight years experience in waste management and ten years experience in environmental analysis areas

Appendix B

SURVEY FORM

HAZARDOUS WASTE MINIMIZATION STRATEGIES IN TENNESSEE



SECTION I — STATUS INFORMATION

Please respond to each question by placing your answer in the appropriate space. These answers will help us compare your responses to those of others.

1. What is the title of your position?

   ____

2. Approximately how many employees are working at this plant?

   0-99 ____ 100-999 ____ 1000 and above ____

3. Do you send RCRA waste to off-site Treatment Storage and Disposal Facilities for disposal?

   ____ Yes ____ No

4. How many waste streams (see Table 1 on the next page) are currently generated at your plant?
   (Circle your waste streams in Table 1 and check one of the categories below.)

   1 to 3 ____ 4 to 10 ____ 11 and above ____

5. What is your plant's primary Standard Industrial Classification (SIC) code?

   ____ ____ ____ ____

1

Table 1. A waste classification system based on treatment opportunities

Waste type	Examples
Waste oils	Spent crankcase oil, industrial lubricants
Halogenated solvents	Spent trichloroethylene, chloroform, carbon tetrachloride
Non-halogenated solvents	Spent acetone, methylethyl ketone
Other organic liquids	Aqueous organic solutions from cleaning or degreasing operations
Metal-containing liquids	Metal finishing solutions (acidic or alkaline)
Cyanide and metal liquids	Neutralized acidic or basic washes with cyanide salts
Other inorganic liquids	Acidic or basic solutions without metals
Oily sludge	Tank bottoms, oil/water separation sludge
Halogenated organic sludge	Halogenated still bottoms
Non-halogenated organic sludge	Still bottoms without halogens
Metal-containing sludge	Electroplating or chrome pigments wastewater treatment sludges
Cyanide and metal sludge	Metal heat treating sludges
Other inorganic sludge	Sulfur sludge, lime sludge
Contaminated clay, soil, sand	Clay filters, spilled material
Dye and paint sludge	Heavy metal and solvent sludges
Resins, latex, monomer	Phenols, epoxy, polyester
Metallic dusts	Primary metal dusts and metal machinery wastes, some emission control dusts from steel and lead industries
Non-metallic inorganic dusts	Precipitator or baghouse wastes, dry lime
Halogenated organic solids	Polyvinyl
Non-halogenated organic solids	Polyethylene, cyclic intermediates
Pesticides, herbicides	Pesticides and production wastes
PCBs	Transformer fluids
Explosives	TNT, wastewater treatment sludges from explosives production
Other	Lab waste chemicals, equipment, containers

SECTION II – WASTE MINIMIZATION PRACTICES

The following statements describe *nine types* of waste minimization practices that you might have undertaken at your plant since September 1985, when the Waste Minimization Regulations of the Hazardous and Solid Waste Amendments went into effect. Please *circle* the number to the right of each statement that indicates the extent to which your plant has adopted these practices since SEPTEMBER 1985 IN ORDER TO MINIMIZE RCRA CONTROLLED WASTES.

Implemented with quantifiable results	Began implementation or planning to begin soon	Evaluated, determined not to implement	Evaluating	Not evaluated or not applicable
5	4	3	2	1

6. Changes in process equipment or technology	5	4	3	2	1
7. Improvements in "housekeeping" or general operations (for example better hazardous material/waste management, purchase practices, waste segregation)	5	4	3	2	1
8. Improvements in employee awareness of waste minimization practices (for example training, rewards, audits, policy statements)	5	4	3	2	1
9. Changes in raw materials used in operations (for example substitution of less toxic materials)	5	4	3	2	1
10. Changes in the final products produced (for example changes in the design, composition, or specification of the end-product)	5	4	3	2	1
11. On-site recycling operations (for example use of potential waste as raw material or reclaiming usable material/energy from it)	5	4	3	2	1
12. Off-site recycling operations (same as number 11 above, but waste is recycled by an outside company)	5	4	3	2	1
13. On-site treatment for volume and/or toxicity reduction (for example incineration, detoxification, neutralization, etc.)	5	4	3	2	1
14. Off-site treatment for volume and/or toxicity reduction (same as number 13 above, but waste is treated by an outside company)	5	4	3	2	1

15. Please check the applicable category below. To what extent do the waste minimization practices you have "implemented" and "began or plan to implement soon" (listed in the first two columns above) represent changes in your overall operations?

_____ Extensive _____ Moderate _____ Negligible

Additional comments:____

____

SECTION III - WASTE MINIMIZATION FACTORS

Please *circle* the number to the right of each statement that indicates the extent of your agreement (or disagreement) with the statements made below in parts A through D.

Strongly agree	Agree	Undecided	Disagree	Strongly disagree
5	4	3	2	1

A. Waste Minimization Regulations of the Hazardous and Solid Waste Amendments, 1984

16.	The Waste Minimization Regulations encourage your company to consider alternative waste management options for disposal of waste.	5	4	3	2	1
17.	Documenting waste minimization in your annual report increases the significance of the Waste Minimization Regulations.	5	4	3	2	1
18.	The Waste Minimization Regulations force your company to better understand the variety of waste streams and their sources.	5	4	3	2	1
19.	The Waste Minimization Regulations encourage your company to reduce waste volume and/or toxicity.	5	4	3	2	1
20.	The Waste Minimization Regulations' certification requirement is an important factor in increasing waste minimization practice(s).	5	4	3	2	1
21.	The Waste Minimization Regulations encourage your company to develop baseline information on the volumes and toxicity of wastes generated.	5	4	3	2	1
22.	Waste Minimization Regulations encourage your company to conduct waste audits.	5	4	3	2	1
23.	Waste Minimization Regulations encourage your company to increase recycling of wastes.	5	4	3	2	1
24.	The land disposal restrictions of the 1984 Hazardous and Solid Waste Amendments are a major reason why waste minimization practices are being implemented.	5	4	3	2	1

B. Economic Factors

25.	The rising cost of hazardous waste treatment/disposal is a major reason why waste minimization practices are being implemented.	5	4	3	2	1
26.	Waste minimization practices are adopted to avoid potential litigation and future liability.	5	4	3	2	1
27.	Low-cost waste minimization practices should be adopted immediately.	5	4	3	2	1
28.	Management considers adopting waste minimization practices only when they are cost-effective.	5	4	3	2	1
29.	Waste minimization practices are too expensive for companies with old facilities.	5	4	3	2	1
30.	Waste minimization practices are likely to increase product costs and thereby make the product less competitive in the market.	5	4	3	2	1

Strongly agree	Agree	Undecided	Disagree	Strongly disagree
5	4	3	2	1

C. Environmental Concerns

31.	Waste minimization practices can conserve raw materials.	5	4	3	2	1
32.	Waste minimization practices decrease the need for hazardous waste disposal.	5	4	3	2	1
33.	Some waste minimization practices should be implemented, even if not cost-effective, in order to enhance environmental protection.	5	4	3	2	1
34.	On-site waste minimzation activities are preferred to off-site waste minimization since they decrease potential transportation risks.	5	4	3	2	1
35.	Enhancing the public image of the company is an important reason for the adoption of waste minimization practices.	5	4	3	2	1
36.	The health consequences of emissions, discharges, and accidental releases to the environment are major factors in adopting waste minimization practices.	5	4	3	2	1

D. Technical Know-How

37.	The lack of detailed knowledge regarding waste streams and their sources prevents the adoption of waste minimization practices.	5	4	3	2	1
38.	The absence of sufficient technical know-how by the staff prevents the adoption of many waste minimization practices.	5	4	3	2	1
39.	Increasing the size of the technical staff would increase the adoption of waste minimization practices.	5	4	3	2	1
40.	Reducing the amount and/or toxicity of hazardous waste is an important element in designing new industrial processes and operations.	5	4	3	2	1
41.	Companies would take advantage of technical assistance in waste minimization practices being offered by either the state or federal governments.	5	4	3	2	1

Additional comments:____

____

42. Would you like to receive a copy of research results?

Yes ____ No ____

Thank you for your help. Your cooperation is greatly appreciated. This completed questionnaire should be mailed in the enclosed postage-paid envelope. If you have questions or comments about this study, please contact me:

B. D. Barkenbus
The University of Tennessee
P.O. Box 8820
Knoxville, TN 37996-4800

If you have any other comments to make about Waste Minimization Regulations, your company's practices, or about this survey, please use the space below.

Appendix C

COVER LETTER FOR THE INITIAL
MAILING OF SURVEY FORM

THE UNIVERSITY OF TENNESSEE
KNOXVILLE

Waste Management
Research and
Education Institute

Dear Hazardous Waste Manager:

We would like to ask for your help. The enclosed questionnaire is part of the doctoral dissertation of Belgin Barkenbus, designed to gain a better understanding of waste minimization efforts undertaken by Tennessee companies. Through your assistance, she hopes to be able to document waste minimization progress in general, and to assess the impact to date of the Hazardous Waste Minimization provision of the Resource Conservation and Recovery Act (RCRA).

Completion of this form should take approximately ten minutes and this survey form can be completed by more than one person. The person(s) completing the form should be familiar with your company's waste minimization practices and the decision-making process that influenced these practices. Please fill out the form as completely as possible. Be assured that the answers are entirely confidential. Your facility's identity will not be used in any report or publication resulting from this research. All responses will be evaluated in groups.

Ms. Barkenbus needs your responses as soon as possible. If you would like to receive a copy of the findings, please indicate so on the last question. A stamped self-addressed envelope is enclosed for your response. She may be contacted at 615/574-6605.

Thank you for your assistance.

Sincerely,

Belgin Barkenbus

B. D. Barkenbus,
Doctoral Candidate
University of Tennessee

E. W. Colglazier

E. W. Colglazier, Director
Waste Management Institute
University of Tennessee

Ernie Blankenship

Ernie Blankenship
Tennessee Association of
Business

Office of the Director: 327 South Stadium Hall / Knoxville, Tennessee 37996-0710 / (615) 974-4251

Appendix D

COVER LETTER FOR THE SECOND
MAILING OF SURVEY FORM

THE UNIVERSITY OF TENNESSEE
KNOXVILLE

Waste Management
Research and
Education Institute

Dear Hazardous Waste Manager:

About two weeks ago we wrote to you seeking your knowledge of your company's waste minimization efforts and your evaluation of the reasons for their implementation. As of today, we have not received your completed questionnaire.

This study seeks information from selected Tennessee companies. Your company was randomly chosen from a list of Tennessee large waste generators who file an annual report with the Tennessee Department of Health and Environment. For research results to be meaningful, it is important that each questionnaire be completed and returned.

This survey form can be completed by more than one person. The person(s) completing the form should be familiar with your company's waste minimization practices and the decision-making process that influenced these practices. Please fill out the form as completely as possible. Be assured that the answers are entirely confidential. Your facility's identity will not be used in any report or publication resulting from this research. All responses will be evaluated in groups.

We need your responses as soon as possible. Completion of this form should take approximately 10 minutes. If you would like to receive a copy of the findings, please indicate so on the last question. A stamped self-addressed envelope is enclosed for your response. B. D. Barkenbus may be contacted at 615/574-6605.

Thank you for your assistance.

Sincerely,

Belgin Barkenbus

B. D. Barkenbus,
Doctoral Candidate
University of Tennessee

E W Colglazier

E. W. Colglazier, Director
Waste Management Institute
University of Tennessee

Office of the Director: 327 South Stadium Hall / Knoxville, Tennessee 37996-0710 / (615) 974-4251

Appendix E

POSTCARD REMINDER FOR FIRST AND SECOND MAILING OF SURVEY

Appendix E

POSTCARD MESSAGE FOR FIRST AND SECOND MAILING OF SURVEY

FIRST POSTCARD REMINDER

About a week ago I mailed a questionnaire "Hazardous Waste Minimization Strategies in Tennessee" to you. If you have completed the form and put it in the mail, you have my sincere gratitude. If not, I would appreciate your doing so as soon as possible.

Your company was selected as one firm in a sample of hazardous waste generators. Since the sample is quite small, every questionnaire is important to producing accurate results.

Sincerely yours,

B. D. Barkenbus
Doctoral Candidate
University of Tennessee

SECOND POSTCARD REMINDER

About a week ago I mailed a questionnaire "Hazardous Waste Minimization Strategies in Tennessee" to you for the second time. Some companies already responded, but I would like to hear from you. If you have returned your form, I thank you very much. If you have not completed it, I would again ask you to complete and return it.

Sincerely yours,

B. D. Barkenbus
Doctoral Candidate
University of Tennessee

Appendix F

COMMENTS FROM RESPONDENTS

Appendix F

LIST OF COMMENTS FROM RESPONDENTS

ADDITIONAL COMMENTS

Group One

"It is more of an attitude and approach" (for statement 39)

"Bureaucracy" (for statement 41)

"Economic & Liability are the driving factors for waste minimization not the cumbersome regulations which often work against minimization practices."

"I would like to see the state be aggressive in bringing new technology in waste minimization to industry."

"Hazardous waste regulations relating to waste activities, inhibit development of on-site waste reduction processess i.e. treatment, incineration."

"Waste minimization presently is a cost-driven, regulation-controlled program."

"State and Federal government do not know enough" (statement 41)

"Business economics cannot be legislated. Hazardous waste notifications for NPDES & POTW permitted systems confuse the data and falsely inflate the data."

"Regulations on top of regulations cause many people to resent and resist government intervention into private enterprises. We need streamlined regulations that are not threatening and cumbersome or costly to comply."

"Waste minimization is most effective when done for economic benefits of the company."

Group Two

"It does not prevent it, it mires things down." (for statement 38)

"I believe companies would use them as a worst case — last resort." (for statement 41).

"A major restriction to the use of State or Federal Technical assistance would be the fear of punitive actions." (for statement 41).

"Extensive research needed to improve raw materials and at the same time improve the product through their use in order to be cost effective. Relative to product cost increase."

"We are already recycling the only waste streams possible. Regardless of the additional regulations that may follow, we will have two waste streams."

"It is kind of tiresome when the state keeps pounding you with new regulations trying to force you to do things that are not possible."

"Raw material changes dictated by customer not internal decision." (for statement 9)

Group Three

"Increasing staff would do nothing, increasing technical knowledge, that would do the job" (for statement 39)

"Questions 6 and 9 are misleading. We changed to a water based ink to reduce the toxicity of our waste and lower our air quality problem, but after several months of trial and error we had to change back to alcohol ink on most operations."

"The state red-tape and insurance for variances, on-site recovery is devastating to the program across the board."

"Bottom line is cost. Wastes are minimized when it is profitable to do so."

"Company can use consultants." (for statement 39)

"Usage and methods of some chemicals do not lend themselves to minimization."

"In 1985 12 (55 gal) waste per 4 mo., now 3 (55 gal) waste per 6 months."

"In 1986 99 drums, in 1987 30 drums."

"Most companies do not trust state agencies. State agencies do not have a reputation for being cost effective." (for statement 41).

"There is too much government 'help' followed by forced requirements." (for statement 41)

.... has an aggressive waste minimization program in addition to the legislative regulations"

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