# AN INVESTIGATION OF THE FACTORS LIMITING COMPOST PRODUCTION AND UTILIZATION IN ONTARIO

A Thesis

Presented to

The Faculty of Graduate Studies

of

The University of Guelph

by

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In partial fulfillment of requirements

for the degree of

Masters of Science

January, 2001

# ABSTRACT


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COMPOST PRODUCTION AND UTILIZATION IN ONTARIO

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Composting organic wastes presents an opportunity to produce a nutrient rich soil conditioner with economic potential while reducing organic waste going to landfill. This thesis is an investigation of the factors limiting compost production and utilization in Ontario.

Mail surveys sent to all (60) large scale composting operations and randomly selected (300) commercial users of compost in Ontario. Of the surveys sent out, valid responses were obtained from 53% and 14%, respectively. Compost producers were concerned with producing quality products and building revenues. Compost users demand a variety of compost products

# Acknowledgments

The idea for this thesis was the collective brainchild of a few people. My inherent odd fascination with waste management combined with the guidance of my advisors made this project possible.

I would like to thank my advisors, Dr. Paul Voroney and Dr. Calvin Chong, for your financial support and academic guidance. Dr. Isobel Heathcote, thank you for serving on my advisory committee and providing me with invaluable advice and comments. This road has at times seemed to be a long one.

Thank you to the Ashton Statistical Laboratory at the University of Guelph provided expertise and assistance with the analysis of this data. I would like to thank the following for their expert advice: Dr. John Fitzsimons, Brad Gugleitti, Ulrica Stoklas, Paul Taylor, and the Composting Council of Canada. Paul van der Werf, thank you for advice, continued support, and encouragement. Trevor Barton, thank you for your advice, insight and sharing that peculiar passion for waste management.

I would like to thank my parents Jöern, Monika, and brother Marcus, for their love, support and encouragement. Although you may not have understood exactly what it was I was doing, I am fortunate that you have been with me the entire time. I would like to thank my fiancé, Douglas J. Johnston, thank you for your love and strength.

Thank you: Herbert, *du warst immer ein grosses vorbilt fur mich, danke fur dein perspectif.* Larissa, for providing me with endless support of friendship. Douglas Mitchell, no matter how much time or distance comes between us, you have always been there. Sarah, we have inspired each other both intellectually and physically - enough said. Richard, fellow Taurean, always provided an ear, a shoulder and a wise word. Donna, for encouraging me to think aloud. Kevin and Tricia, making me feel at home - away from home. "Marmilade" & family, thank you for reminding me that it is possible to keep going long after you think you cannot. The Town of Orangeville, to Gary Kocialek and Jean-Paul Marchildon especially, thanks for always leaving the door open.

Also JPW, Cynthia, Lesley, Melissa, Dave, Ian, Elmar, Adam, and Jeff (thanks for PFD); each of you have inspired me in your own ways. To all friends and family, old, new, reacquainted, far, and near. Finally, I would like to thank Terry Gillespie and the Land Resource Science family for your support and friendship.

I met a journalist / scriptwriter on a flight from Toronto to Winnipeg.
He told me that writers liken their work to the composting process.
He said,
"First you collect the garbage and store it in your brain.
Then, you let it rot in your mind.
Finally you end up with a fertile product."

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# 1.0 Introduction

Compost is a natural product derived from the decomposition of organic matter. There are various definitions of composting, Haug (1980) defines composting as "the biological decomposition and stabilization of organic substrates under conditions which allow development of thermophilic temperatures as a result of biologically produced heat, with a final product sufficiently stable for storage and application to land without adverse environmental effects". Compost is defined as a solid mature product resulting from composting, which is a managed process of bio-oxidation of a solid heterogeneous organic substrate including a thermophilic phase (CCME, 1996).

Compost can be used for many beneficial applications such as enhancing the physical and chemical characteristics of soils (Golueke, 1972; Hughes, 1980; Manser, 1996; Sikora, 1996). Not only does compost provide a method of waste diversion, but also it can be used in landscaping, horticultural, agricultural, and land remediation applications. Growers, nurseries, topsoil blenders, and landscapers use compost in large quantities as a soil or potting amendment.

Composting programs have been a part of municipal recycling programs worldwide since the late 1980s when municipalities had to provide recycling programs for their residents (MOE, 1993). These programs were initially concerned with such yard wastes as leaves, brush, and Christmas trees (Barton, pers. com., 1999) but now include agricultural and food wastes. As with most businesses, a successful composting facility must produce a marketable quality

product while remaining operationally efficient. Composting facilities, by the very nature of their business, must also practice sound environmental stewardship.

In Canada, organic matter makes up 30 to 50% of the total residential waste stream volume (Antler, 1997). In a well-managed system, composting can reduce the volume of waste landfilled by up to half (Antler, 2000; Manser, 1996). However, the full potential for composting materials generated in residential, commercial, and other areas, such as agriculture, has not yet been realized. Estimates of the amount of materials currently being composted may be as low as 25% of the total disposable organic material (Antler, 1999) even though the number of Ontario municipal composting programs and the quantities of compostable materials processed have been increasing during the past decade (Table 1.1), as has also the number of households having access to these programs.

Table 1.1 Changes in composting activity of centralized composting programs between 1994 and 1999 (MOE, 2000)

| Year | 1994 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|
| Number of programs | 30 | 32 | 67 | 74 | 77 |
| Number of municipalities | 152 | 150 | 241 | 235 | 217 |
| Households with access to service (000's) | 3070 | 3323 | 3560 | 3746 | 3874 |
| Tonnes processed (000's) | 149 | 219 | 280 | 290 | 281 |

## 1.2 Objectives

The objectives of the research were:

(i) to identify the factors limiting the large-scale production of compost; and

(ii) to identify the factors limiting the commercial utilization of compost

This research was conducted by sending mail surveys to producers and users of compost in Ontario.

# 2.0 Literature Review

## 2.1 Organic Waste Diversion

In March 1989 the Ontario government implemented Canada's Green Plan and set targets of 25% reduction of municipal waste going to landfill by 1992 and 50% by the year 2000 (Folliet-Hoyte, 1996). By 1992 the province had achieved 21% diversion (CIELAP, 1992) but by 1999, had fallen short of these targets, disposing 35% less waste per capita than in 1987 (Pope, pers. com., 2000).

Compostable organic matter makes up 31% to 60% of the residential waste stream (CIELAP, 1992; Clark *et al.*, 1981; Criner, 1996; Diaz *et al.*, 1982). In a study of communities in the northeastern United States, the Institute for Local Self-Reliance (1991) in Washington D.C reported that it was possible to obtain composting rates of greater than 35%.

According to the 1998 Annual National survey by the Composting Council of Canada, 344 operations across Canada received 1,650,000 tonnes of compostable waste. Of this, 519,300 tonnes (or 33%) were composted by 71 operations in Ontario (Antler, 1999). The Ontario Ministry of the Environment (MOE) reported that in Ontario 281,000 tonnes of organic matter were diverted from landfill in 1999 by large-scale composting programs and an additional 112,000 tonnes diverted through backyard composting programs (MOE, 2000). Elsewhere in Canada, Quebec processed 565,000 tonnes, Atlantic Canada 253,500 tonnes, and Western Canada 328,900 tonnes of compostable material in 1998.

## 2.2 Compost production

Composting operations must manage factors such as aeration, moisture, and temperature to maximize the efficiency of the composting process (Manser, 1996). The active phase of composting is characterized by intense microbial activity producing excess heat and followed by the curing stage when compost temperatures decline (Adani *et al.*, 1997). The active phase can take from 21 days to six months (Poplrasert, 1996).

The MOE (1991) requires that compost reach a critical minimum of 55°C for a three-day period to allow sufficient pathogen kill to occur. If the critical temperature and time requirements are not met, the materials must be disposed of at a waste disposal site or be re-incorporated into the composting process from the beginning stages (MOE, 1998).

The curing stage can last for up to 6 months and is complete when the compost is not able to reheat greater than 20°C above the ambient temperature (MOE, 1998). The finished compost should be brown or dark brown in colour, have a sweet earthy smell, and be damp when squeezed in your hand (Chong, 1996a). After the compost product has cured and met MOE guidelines for quality, it can be given away or sold for use in landscaping, horticulture, agriculture, reclamation and remediation (Antler, 2000, Pinamonti *et al.*, 1996). Most finished composts are screened and/or blended with topsoil before they are sold to enhance aesthetics and quality (Goulin, 1994).

There are four major methods of creating compost on a commercial scale. These are windrow, static pile, invessel, and sealed container composting. Costs and duration of the composting process differ between each of the methods.

### 2.2.1 Windrow composting

Windrow composting involves the heaping of organic materials in long rows. Ideally, the size of these rows, which are usually triangular in cross-section, vary from 1.5 m to 1.8 m in height and from 2.4 m to 4.5 m in width, and is determined largely by the method of mixing (MOE, 1990). Rows must be periodically turned to provide continuous aeration for the microbes so that the piles do not become anaerobic (Diaz *et al.*, 1993; MOE, 1990). Windrows are actively composted for three to five months (Barton pers. com., 1999), followed by a period of curing or stabilizing for an additional three months. Windrows are usually aerated by turning machines or front-end loaders (BioCycle, 1989; Diaz *et al.*, 1993). Use of a turning machine results in more thorough mixing (Diaz *et al.*, 1993; Martegain, 1985).

Fresh feedstocks (such as organic matter consisting of household waste, shredded yard waste, leaves, etc.) are added at one end of the windrow, and removed from the other as the materials decompose. Timely frequency of turning can reduce the residence time of the active compost phase (Diaz *et al.*, 1993). Less turning reduces moisture loss (MOE, 1990; van der Werf, 1987). Bulking agents such as wood chips are often mixed with the feedstock in small

proportions (Anonymous, 1994; van der Werf, 1995; Walker *et al.*, 1989) to improve aeration and drainage.

### 2.2.2 Static pile composting

Static pile composting is a modified form of windrow composting. It involves piling the organic matter into a single heap and aerating it by forcing air through the pile; in some cases the pile may be turned with a front-end loader (Diaz *et al.*, 1994; Gotaas, 1956). Piles should be loosely stacked to ensure airflow throughout the pile and to avoid the pile compressing under its own weight (Gotaas, 1956; Manser *et al.*, 1996). Typical heights for piles vary from 1.0 to 1.8 m, and sizes may be increased in cooler climates to maintain higher temperatures (Golueke, 1994). To maximize the efficiency of static pile composting, it is especially important that a variety of materials, including a bulking agent such as wood chips, be thoroughly mixed with the feedstock to prevent clumping and to ensure uniform moisture throughout the pile (MOE, 1990).

The City of Guelph uses the static pile method, but only for the curing portion of the composting process. The curing stage can take from 6 weeks up to 3 months to complete (Barton, pers. com., 1999; Diaz *et al.*, 1993).

### 2.2.3 Invessel composting

Invessel (or cell) composting, an increasingly common method of composting (Walker, *et al.*, 1989) occurs indoors where vessels or channels are constructed of concrete. Dimensions of these channels are 2.0 m wide by 3.5 m high at the City of Guelph (Barton, pers. com., 1999). Channels are loaded with compost, watered, ventilated from beneath the channels, and turned periodically to promote microbial activity. The compost is turned with a turning machine that moves the compost progressively through the channels (van der Werf, 1995). The composted material is removed at one end while fresh feedstock is added at the other. Typically, invessel composting time is less than that of windrow composting time because of reduced heat and moisture losses (Barkdoll *et al.*, 1994; Halet *et al.*, 1996).

### 2.2.4 Sealed container composting

Sealed container composting technology is less common than other forms of composting because the technology required is more expensive to operate (Diaz *et al.*, 1994). In this type of composting, re-circulated air is forced throughout the cell (Manser *et al.*, 1996). All parameters (temperature, moisture and airflow) are monitored via computer and adjustments are made based on computer settings and the operator's discretion.

The Region of Peel in Ontario uses the Herhof Biocell Stystem to compost 3,360 tonnes annually of organic kitchen and yard waste from 7,500 households. The system consists of eight 60 $m^3$ cells that can potentially produce 1,500

tonnes of compost per year. The active composting stage takes seven days, including warming up the materials and the required three days at 55°C. Thereafter, the compost is cured for 35 days (Roulston, 2000).

## 2.3 Compost use

Composts are used as a soil conditioner and nutrient source in agriculture and in land reclamation of areas that have been strip-mined or eroded (Diaz *et al.*, 1993; Golueke, 1972; Shiralipour *et al.*, 1994). Compost benefits soil by improving soil structure and fertility and by increasing soil water retention capacity and pH buffering capacity (Chong, 1996b; Golueke, 1972). Improved crop yields have been shown through the use of compost (Hughes, 1980; Joosse, 1992; Kitto, 1988; Shiralipour *et al.*, 1998; Sikora, 1996). Compared to peat moss or bark mulch, compost absorbs water more readily (Golueke, 1972; Pinamonti *et al.*, 1996). Compost must be blended with topsoil or sand to be used effectively.

When blended with topsoil, compost products are commonly used in landscaping, in growing operations such as nurseries and garden centres (Antler, 1999; BioCycle, 1994a; Gouin, 1998; May *et al.*, 1994; Nelson *et al.*, 1995). Golf courses also use compost to enhance the soil properties under turf (Block, 1997; Resource Conservation and Development of Northeast Iowa, 1998).

Aggressive marketing can ensure that compost products to achieve maximum market value. Successful steps to compost marketing include: product production, product research, promotion, education, sales, and distribution

(Alexander, 1998; Segall *et al.*, 1990). Diaz *et al.* (1994) also suggest the following factors: market continuity, including product quality, availability, constant specifications, and pricing.

## 2.4 Compost quality standards and organizations

Various institutions have set standards and guidelines governing the production and quality of composts in Ontario, Canada. The Ontario Ministry of the Environment (MOE), Canadian Council of Ministers of the Environment (CCME) and Agriculture and Agri-Food Canada (AAFC) are the government institutions that contribute guidelines and standards to the composting industry. There are also two private organizations which aid in the distribution of information and marketing of compost in Canada: the Bureau de Normalization du Quebec (BNQ), and the Composting Council of Canada (CCC).

### 2.4.1 Canadian Council of Ministers of the Environment and Agriculture and Agri-Food Canada

In January 1993, a meeting of the BNQ, the AAFC, and Environment Canada resulted in the formation of the Solid Waste Management Task Group, a part of the CCME. Compost quality guidelines and criteria were developed for foreign matter content, maturity, organic contaminants, pathogens, and trace elements of commercial compost production (Table 2.1).

The CCME guidelines (CCME, 1996) recognize two categories of compost, Category A and Category B. Category A compost may be used in any

application, such as agricultural lands, gardens, horticultural operations, and nurseries. The BNQ (1996) states that criteria for this category are achievable by using source-separated municipal solid waste feedstock. Category B compost has restricted use but must meet Category A requirements for trace elements. This compost may require authorization by provinces or territories before being used (CCC, 1997).

Agriculture and Agri-Food Canada regulations recognizes only one class of compost, based on the CCME's Category B and the BNQ's type B compost; criteria are based on trace elements, pathogenic organisms, maturity and the presence of sharp objects (Table 2.1) (Antler, 1997). Neither the CCME nor AAFC support the adoption of standards for organic contaminants in compost at this time (BNQ, 1996).

### 2.4.2 Ontario Ministry of the Environment

In Ontario, the MOE regulates the commercial production and use of compost, using guidelines based on CCME standards for trace elements, foreign matter, and pathogens. The Ontario Environmental Protection Act (Regulation 347) governs overall waste management in Ontario. The Environmental Assessment Act is utilized in siting procedures of composting facilities, and the Ontario Water Resources Act regulates discharge to surface and ground water and specific factors such as storm water run-off (MOE, 1990).

The "Draft Guidelines for Aerobic Composting Facilities and Compost Use" outline quality objectives for compost produced in Ontario (MOE, 1998). Maximum concentrations for trace elements are reported in Table 2.1. These standards are consistent with CCME "category A" compost. Foreign matter is allowable to a maximum of 1.0% by volume for plastic particles and non-biodegradable matter (> 3 mm in any dimension). In specific situations (e.g. where human waste is composted), the MOE may amend the parameters to be measured. Compost that fails to meet the moisture, temperature, and trace element criteria set by the MOE is considered a waste. Therefore, MOE approval is required for use or for disposal of this material (MOE, 1998). Maturity of compost is determined based on CCME standards; the compost must pass two out of three of the following tests:

(i) C:N ratio must be less than or equal to 25; and
(ii) The oxygen uptake rate must be less than 150 mg $O_2$ $kg^{-1}$ of organic matter per hour; and
(iii) (a) The germination test of cress and radish seeds.
(b) The compost must be cured for a minimum of 21 days and the compost must not reheat upon standing to greater than 20°C above ambient temperature.
(c) The compost must be cured for a minimum of 21 days and the reduction of organic matter must be greater than 60% by weight.

(MOE, 1998 p23)

If these tests are not chosen, the compost must be cured for a period of at least six months during which it must be turned at least once a month.

Table 2.1 Limits for trace element concentration, foreign matter, and pathogen limits for compost (CCC, 1997; BNQ, 1996; CCME, 1996; MOE, 1992)

| **Trace Elements** (PPM) | Type AA & A* Category A** | Type B Category B AAFC | MOE |
|---|---|---|---|
| Arsenic (As) | 13 | 75 | 10 |
| Cadmium (Cd) | 3 | 20 | 3 |
| Cobalt (Co) | 34 | 150 | 25 |
| Chromium (Cr) | 210 | 1060 (BNQ only) | 50 |
| Copper (Cu) | 100 | 757 (BNQ only) | 60 |
| Mercury (Hg) | 0.8 | 5 | .15 |
| Molybdenum (Mo) | 5 | 20 | 2 |
| Nickel (Ni) | 62 | 180 | 60 |
| Lead (Pb) | 150 | 500 | 150 |
| Selenium (Se) | 2 | 14 | 2 |
| Zinc (Zn) | 500 | 1850 | 500 |

| **Foreign Matter** | | | |
|---|---|---|---|
| BNQ Standard | Type AA | Type A | Type B |
| Content as percentage of oven dried mass | <= 0.01 | <= 0.05 | <= 1.5 |
| Maximum dimensions (mm) | 12.5 | 12.5 | 25 |
| CCME Standard (mm) | 25 | 25 | 25 |
| AAFC Standard (mm) | 3 | 3 | 3 |

| **Pathogens** | | |
|---|---|---|
| Organization / criteria | faecal coliforms (MPN/4g) | Salmonellae (MPN/4g)*** |
| BNQ | < 1000 | None |
| CCME | < 1000 | < 3 |
| AAFC | <1000 | < 3 |

* Type = BNQ standard
** Category = CCME standard
*** MPN/g = Most probable number per gram of total solids

This table describes the various limitations determined by the CCME, AAFC and BNQ. The MOE Certificate of Approval (C of A) determines the limitations a composting facility must follow. Other requirements covered under the C of A include transportation of materials to and from the site, air quality and odour control. A facility is required to submit an annual report to the MOE describing their annual activities and explanations regarding deviations from the

original guidelines outlined in the initial site approval. Composting facilities are required to retain all documentation for at least two years, and for it to be readily available to and MOE officer on request.

### 2.4.3 The management of organic waste in Ontario

In 1993 the MOE enacted new waste reduction regulations (Bill 7), otherwise known as the "3R's Regulations", which defined compulsory rules and requirements in the province of Ontario (MOE, 1993). Municipalities with populations of 5,000 or more were obligated to compost leaf and yard waste if they were collecting it. Those with a population of 50,000 or more had to provide a collection system (curbside or depot) for leaf and yard waste and compost it.

Bill 7 provided municipalities with the power to administer waste management programs and enforce them specifically as follows:

> 208.2 A local municipality may pass by-laws to establish, maintain and operate a waste management system. 208.3 (1) The power under section 208.2 includes the power to (a) acquire land in any local municipality or in territory without municipal organization; (b) acquire, establish construct, operate and maintain facilities and services including buildings, structures, pipes, machinery or equipment; (c) extract produce, manufacture, advertise, sell, supply and distribute products (including resources, commodities, energy, gases, hot water and steam) obtained from waste and waste by-products, including products obtained by reducing, recycling and reusing waste and waste by-products; (e) provide educational programs an otherwise promote the waste management system.
>
> (Ontario Municipal Act, 1993)

Since then, municipal waste collection has become a more prominent service in Ontario.

### 2.4.4 Bureau de Normalization du Quebec

The BNQ is a voluntary, industry-based organization that reflects government regulations and develops voluntary industry standards (Antler, 1996). This organization regulates safety and labeling and endorses products that meet these standards. Compost is classified into three types by the BNQ: AA, A, and B, (Table 2.1). These types are differentiated based on trace element and foreign matter contents (Antler, 1997; BNQ, 1996).

When the BNQ standards were written, there was little information regarding contamination of organics (such as Poly chlorinated biphenols and pesticides) in compost. The BNQ now re-evaluates the presence these contaminants on a case by case basis (BNQ, 1996), with emphasis on dioxins, furans and pesticides. The BNQ encourages, but does not mandate, compost producers to adopt the voluntary standards for compost (MOE, 1998).

### 2.4.5 Composting Council of Canada

The Composting Council of Canada, a non-profit, member-driven organization, serves as the central resource and network for the composting industry in Canada (Antler, 2000). The Council produces annual surveys of centralized composting operations in Canada and hosts annual conferences and workshops. This organization has been active for over a decade and is a resource center for composting operations, users of compost, and other institutions.

Compost quality standards and organizations are necessary to maintain high standards and to promote growth and development of the industry. These institutions and organizations help to protect users of compost as well as the natural environment.

## 2.5 Survey design and administration

Surveys are commonly used to obtain research information. Three standard options exist for surveying (i.e. administering questionnaires), personal interview, telephone and mail survey (de Vaus, 1986; Nachmias, 1976; Rea *et al.*, 1997). Of these, the mail method is the most cost-effective option. Dillman (1978), Fowler (1984) and Rea *et al.* (1997) concur that the more attractive and professional a survey letter appears, combined with a follow up contact, the greater the likelihood of receiving a response. Rea *et al.* (1997) suggest that proper procedures can yield mail survey response rates from 50 to 60%, Dillman (1978) obtained up to 70% response rates.

Dillman (1978) outlines the advantages and disadvantages of different survey methods. Telephone surveys require more time waiting for return calls or returning missed calls if respondents are unavailable to complete the survey at the time of the initial call. In addition, the inconsistency of asking questions is a limitation with this method of surveying. Furthermore, if research facts are required, telephone surveys could be time consuming. If survey participants provided answers on the spot responses were not as accurately answered as when the participant had a chance to examine the question and to prepare a

response (Dillman, 1978; Jackson, 1988).

Although mail surveys are more applicable to geographically dispersed populations, Nachmias (1976) cautions that the following limitations are inherent with the mail survey method:

(i) they can only be used when the questions are simple and straight forward,
(ii) the answers have to be accepted as final,
(iii) the researcher cannot be sure that the right person completes the questionnaire, and
(iv) the respondent can see all the questions before answering any one of them, so the various answers cannot be regarded as independent.

Mail survey questions should be clearly understood and relevant to the topic (Babbie, 1995; Jackson, 1988). Questions should be neutral, or be void of emotion or negative terms, and should be clear and direct to avoid confusion (Rea *et al.*, 1997). Questions may be asked in open or closed-ended form, as scale interval variables, or multiple responses. Closed-ended questions are most common, provide a fixed list of alternatives to the respondent, and are more likely to provide a greater uniformity of responses that will be more efficient for statistical analysis than open-ended questions (Babbie, 1995; Fowler, 1984).

A disadvantage of closed-ended questions is that respondents may be unsure how to best answer the question. This uncertainty can be alleviated by providing an exhaustive list of choices and the "other _____" option (Babbie, 1995; Rea *et al.*, 1997). Open-ended questions provide freedom to the respondent but they may also require interpretation, are more difficult to analyze, and may also require follow-up contact (Nachmias, 1976). Closed-ended

questions can create bias but are beneficial for ensuring the consistent administration of questions to a population.

Interval scale variable or multiple response type questions provide clearly defined categories as options to the participant. Categories should be equal and have clearly defined boundaries to be ranked by the participant (Rea *et al.*, 1997). If the respondent is not asked to rank their responses, the questions are known as a multiple response. While multiple response type questions are easy to ask and answer, the major drawback is that they may introduce bias (Nachmias, 1976).

Thus, the mail method is the most practical for surveying a broad geographical area and for allowing the respondent to take time to research questions requiring specific responses.

## 2.6 Statistical analysis

Analysis of non-parametric data, such as from closed-ended mail surveys, is accomplished by using cross tabulations, the Mann Whitney U test, and assigning error to the percentage responses by calculating variance of proportion (Fitzsimons, 1998; Noursis, 1997; Rowntree, 1981). The Mann Whitney U is a t-test used to test the responses of non-parametric data. Cross tabulations are used to examine the relationship between variables that have a small number of values or categories (Noursis, 1997). The common method for determining confidence intervals is by calculating variance of proportion. Confidence intervals in combination with cross tabulations and significance testing using the Mann

Whitney U test are acceptable methods for analyzing data collected from surveys (Bradley *et al.*, 2000; Dolan *et al.*, 2000).

# 3.0 Methodology

A series of interviews and site visits to composting operations in Ontario were conducted during the summer and fall of 1998. Two surveys were developed based on meetings with composting operators and industry experts, and mailed to (a) compost operators (60) and (b) commercial users (300) of compost in Ontario during the fall of 1998. The mail method was chosen because it was cost effective method for a survey of this length.

## 3.1 Preliminary survey preparation

The development of the operator survey began with a series of site visits and interviews at 11 composting facilities in southern Ontario. The information gathered during these meetings was utilized as a guideline work in developing the survey. Open and sometimes non-specific questions were chosen in anticipation that operators would be willing or comfortable to answer them; and invasive questions were avoided. Initial interviews were based on a set series of questions. After the interviews were completed, the responses formed a pattern on which the final mail surveys were based. The questionnaires were designed to prompt answers with options, yielding more replies. This method made it easier to tabulate and analyze the results.

The operator survey was developed from an initial group of questions used to interview operators of composting facilities. These questions included ownership of the operation, marketing and sales issues, types of equipment used in the operation, and the methods and technology used to process the waste. Related questions were developed from interviews with the compost operators and included odour management, community relations, types of products produced, and others on the attitude relating to the management of organic wastes.

### 3.1.1 Operator survey

A list of 83 composting operations in Ontario, obtained from the Composting Council of Canada, was cross-referenced with additional information from "Survey of Research Projects in Canada" (Otten, 1993). Sixty operator surveys (Appendix 1) were mailed to municipal and privately operated composting facilities. Eleven operators were pre-contacted and personally interviewed, and informed of the pending survey. Numerical survey results numbers were rounded to one decimal place, therefore totals in charts may exceed 100%.

### 3.1.2 User survey

A list of 1,725 members was obtained from Landscape Ontario. The list was divided into five categories; garden centre commodity group (116); growers commodity group (185), landscape contractors commodity group (606), lawn care

commodity group (396); and grounds management group (422). Members from the first three groups (total 937) were considered to be potential primary users of compost under the categories of (i) garden centers, (ii) growers, and (iii) landscapers. The method of sampling was applied from Babbie (1995) using the following equation: sampling interval = population size / sample size (907/ 300 = 3) and required every third address to be selected from the list for the survey.

### 3.2 Survey design

The survey was designed in an attractive easy to read manner and the check box method was used to facilitate ease of completion of the survey (Fowler, 1984). The surveys also included a section for comments as well as an opportunity for the participant to request a copy of the results. Every effort was made to make the survey appear professional and user-friendly. Confidentiality of responses was stressed.

Types of questions included: closed-ended, multiple response and scaled. Phrases from interviews were utilized to create some of the options provided for these questions. Wherever possible, a space for "other" was made available.

Respondents were encouraged to check "any that apply" but not asked to rank their responses (e.g. first, second and third). To determine how the respondent rated the growth of the operation, the phrases "growing substantially", "growing slowly", and "having difficulty" were used instead of a numbered scale to facilitate a quicker response.

The user survey was similar to the operator survey, but shorter. There were indications that this sample population might not be as receptive in responding to the survey (DiGiovanni, pers. com., 1998). Unlike the operator surveys, the user surveys were not followed-up by telephone due to the larger numbers involved.

Both operator and user surveys were mailed at the same time. Each package contained a survey with a covering letter outlining the purpose of the research and introducing the researcher (Appendix A and B). Self-addressed postage-paid return envelopes were provided to encourage return of the surveys.

### 3.3 Analysis of surveys

The compost operator survey was analyzed by (i) examining the data from the whole survey; and (ii) comparing the responses of publicly and privately owned operations. The operator survey was divided into four sections: (i) administrative, (ii) technical, (iii) marketing / product sales, and (iv) general questions on waste management. The volume of compost produced or used were not of major concern since this information can be obtained from other sources.

### 3.4 Statistical methodology

The surveys and summarized responses including measures of error ($P<0.05$), approximate 95% confidence intervals based on the normal approximation to the binomial distribution [$p \pm 1.96*\text{sqrt}(p*(1-p)/n)$], are in appendices A and B.

The analysis of responses to individual questions was performed by constructing confidence intervals for the proportion **p** of respondents who answered a specific question a particular manner (Mendenhall, 1994; Snedecor 1989; Steel *et al.*, 1980). For example, if, out of **n** operators surveyed, **x** selected indoor windrow composting as an answer to question 12 in the operators' survey, then the observed proportion **p** of indoor windrow composters would be given by **x/n**. The 95% confidence intervals were constructed using the normal approximation to the binomial distribution, as follows:

$$\mathbf{p \pm t_{(n-1,\ .025)} * sqrt\ (p(1-p)/n)}$$

**n** is the number of surveys sent out

**p** is the observed proportion

$t_{(n-1,\ .025)}$ is the 2.5% critical value of the Student's t distribution on **n-1** degrees of freedom

The normal approximation is valid for large **n** and moderate **p**. Very few extreme values of **p** were observed in this study, and although **n** was not particularly large, the normal approximation tended to agree with other methods, including the log and logit transformations, and was therefore chosen for simplicity. One of the limitations of the normal approximation is that a bounded

distribution is being approximated by an unbounded one, so that values of **p** outside the range (0, 1) can be obtained. The calculated confidence limits however, were all between 0 and 1, therefore this was not an important problem (Mendenhall, 1994; Snedecor 1989; Steel *et al.*, 1980).

Cross tabulations were used to determine if a relationship exists between two questions. Differences were reported only when observed to be statistically significant. The Mann Whitney U test was used to test the strength of relationships between variables, (i.e. the responses of public and private compost operators). These tests were done using the Statistical Package Social Sciences (SPSS, 1997).

# 4.0 Results

Of the valid operator surveys sent, (68%) were returned, and of these, nine (15%) were not useable due to improper completion or overlap of jurisdiction (e.g. there were some amalgamations of municipal jurisdictions). The data from 32 (53%) surveys were considered valid for analysis. The total number of compost operators identified by this survey is 60.

Of 300 surveys mailed to potential users of compost, 17% were returned and 14% of the 300 were valid.

Section 4.1 describes responses from selected from 58 questions of the operator survey. Section 4.2 describes the responses from the compost users (23 questions). All responses including confidence intervals ($P<0.05$) are found in appendix A and B.

## 4.1 Operator survey results

Of the 32 composting operations, 22% were privately-owned and 72% were publicly-owned; 9% were a combination of public and private ownership, and were excluded from further analysis (Fig. 4.1).

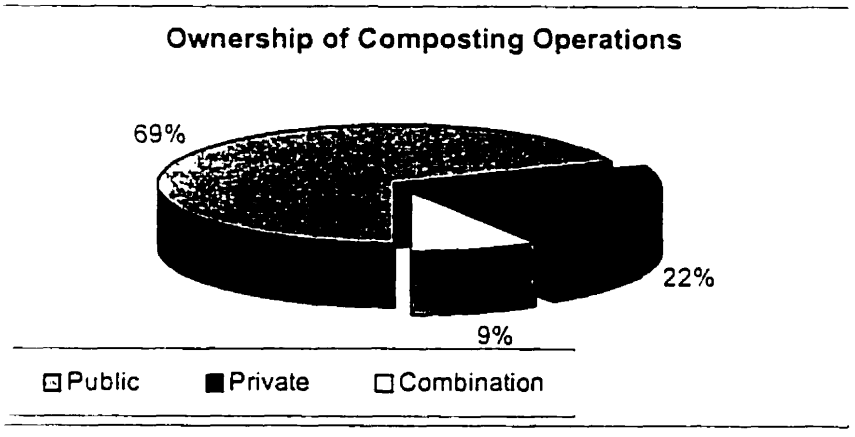


Figure 4.1 Ownership of composting operations

Managers were most likely to fill out the survey in both public (78%) and privately owned (57%) facilities. Overall, owners completed only 9% of the surveys. In privately-owned operations technicians, operators, labourers, and/or coordinators did not fill out any surveys.

Publicly-owned operations employed fewer staff than private facilities. The mean number of full-time staff at private operations was 15 (maximum = 70, minimum = 2); the mean number of full-time staff at public operations was two (maximum = 8, minimum = 1). Privately-owned facilities showed slightly more variation in their seasonal employment, that is, 29% employed part-time staff in the summer vs. 13% for public operations.

Most composting operations, public (63%) and private (86%), have initiated their facilities since 1990. One privately-owned operation started in 1955. More than half (56%) of privately-owned facilities took more than two years to start operating whereas almost half (43%) of public operations began operating in less than one year.

Sixty-three percent of composting operations reported that their revenues were equal to their expenses. The second most common response was that revenues were falling short of expenses in both public (17%) and private (29%) operations. About one-third of both private (29%) and public (30%) composting operations had previously received funding. Privately-owned (14%) operations currently do not receive funding as often as publicly-owned (35%) facilities.

Most publicly-owned operations reported that business had improved substantially whereas most privately-owned facilities reported slow growth. Few in each case indicated that business was "challenging" (was difficult) (Fig. 4.2). A significant difference was observed at the 95% level between public and private responses.

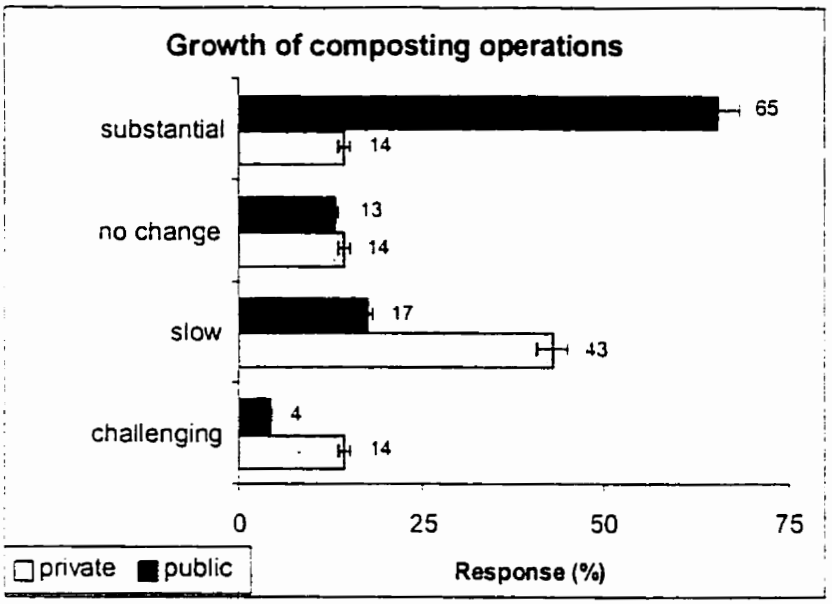


Figure 4.2 Comparison private and public - Growth of composting operations

Most composting operations were located relatively close to a landfill site that accepts compostable materials. The average tipping fee at a landfill site ($59.50 per metric tonne) was almost three times that of the tipping fee at composting facilities ($22.83 per metric tonne). In some cases, both private and public facilities did not charge a fee.

Publicly-owned facilities most commonly used indoor windrow (87%) composting, whereas privately-owned facilities were more likely to use the outdoor windrow method (86%). Static pile composting was slightly more common amongst privately-owned operations (indoor 29%; outdoor 57%) than public (indoor 26%; outdoor 17%). Invessel (public 9%; private 29%) and sealed container (public 4%; private 43%) technologies were used significantly less at both privately-owned and publicly-owned facilities ($P<0.05$) (Fig. 4.3).

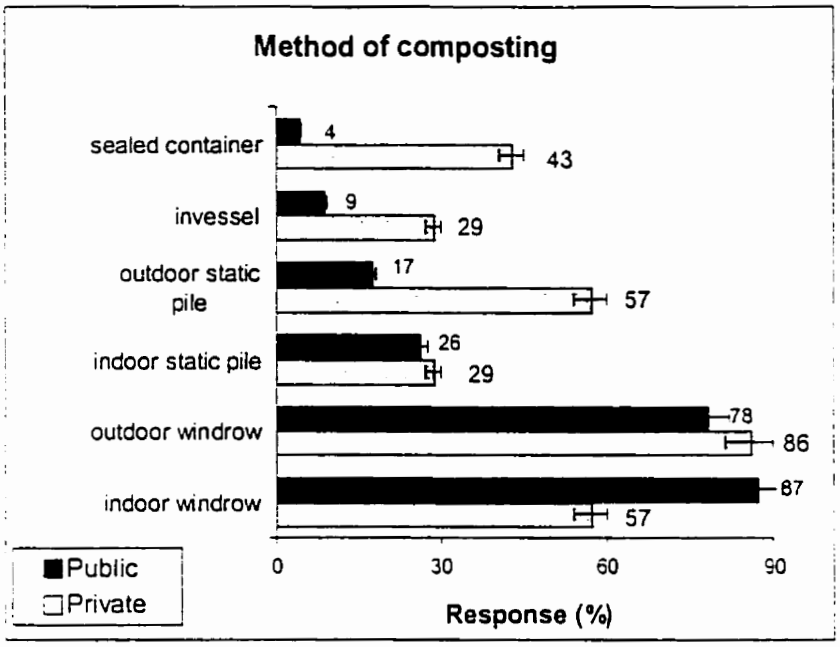


Figure 4.3 Comparison private and public - Method of composting

The most popular types of equipment used in publicly-owned operations were front-end loaders, grinders, and screens (Fig. 4.4). Equipment commonly used in composting operations includes loaders (65% public, 43% private) and turning machines (17% public, private 43%). This coincides with the greater number of invessel systems reported in private facilities; windrow turners would be the only way to turn compost in vessels. Grinders were also common (44% public, 14% private), although not many were seen during site visits. Dump trucks were more common at private facilities (29%) than at (9%) public facilities. Dump trucks are used on-site as well for providing delivery of compost products. It is possible that these vehicles are used for the composting operation on occasion but are not directly allocated to the composting facility in publically operated operations. Thirty-five percent of public facilities noted that they rented equipment. Comments regarding maintenance of equipment were similar across the categories of equipment, almost half (44%) of all operators reported that maintenance on their equipment was acceptable. Windrow turners and grinding

machines were the most difficult or expensive to maintain, while front-end loaders had a low maintenance.

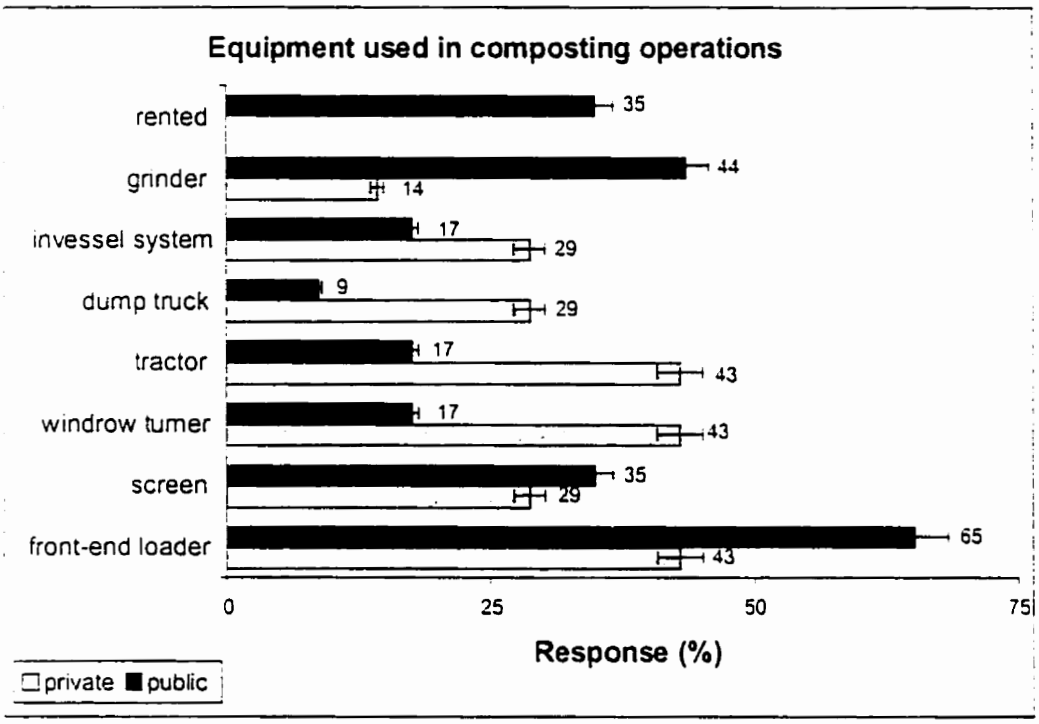


Figure 4.4 Comparison private and public – Equipment used in composting operations

Private composting facilities reported significantly shorter composting times than public facilities ($P < 0.05$). Most public facilities (65%) required four or more months, whereas private facilities reported less than one month (29%) or 2 to 3 months (43%). One publicly-owned facility cured compost in less than one month, while most facilities required up to four months.

Municipal yard waste was the most common type of waste accepted at both private (86%) and publicly-owned (87%) facilities. Privately-owned facilities typically composted a greater variety of materials including agricultural wastes (private 57%, public 22%) and sludge (private 71%, public 9%) (Fig. 4.5).

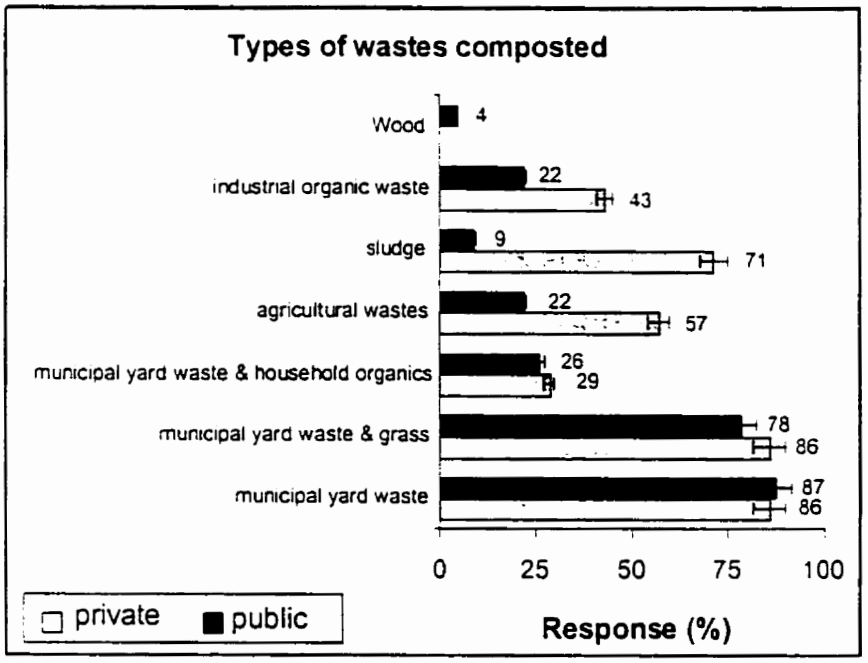


Figure 4.5 Comparison private and public - Types of wastes composted

Materials rejected at publicly-owned facilities include processed or large wood items (30%), meat and household organics (22%), refuse grass and yard waste (9%); and 9% specifically refused acidic plant matter. Plastics and household contaminants are major concerns for private (71%) public (65%) operations.

Almost one-third of publicly-owned facilities conduct operations as dictated by weather conditions to deal with odour complaints, whereas 28% of privately-owned facilities stopped operations. Thirteen percent of publicly-owned operations reported they had no odour complaints. Publicly-owned facilities were

more likely to investigate the odour complaints while private operations were more likely to stop operations (Fig. 4.6).

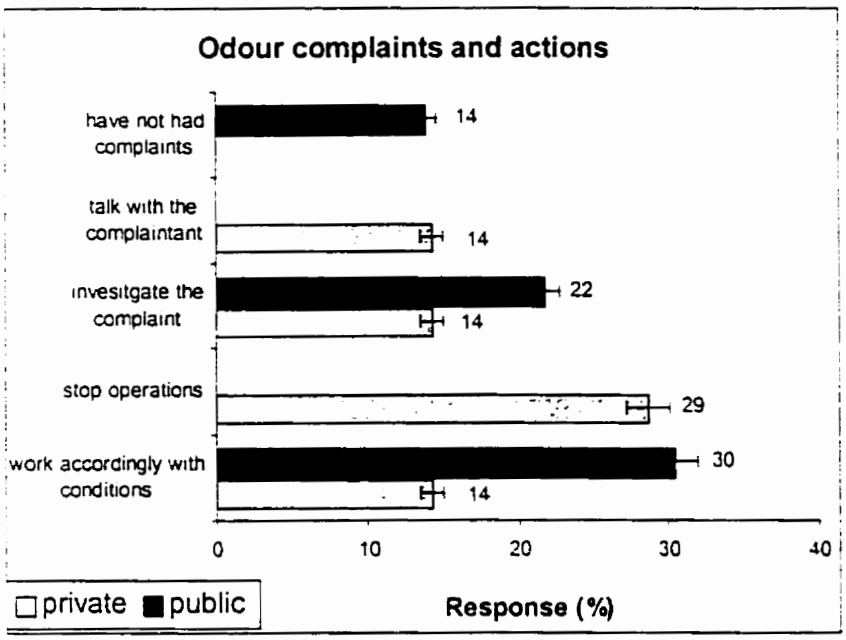


Figure 4.6 Comparison public and private - Odour complaints and actions

Compost quality was most often attributed to the quality of incoming materials, 29% of privately-owned operators, and 22% publicly-owned operators. Moisture content of the incoming material (14% private; 17% public) was also a management concern.

Privately-owned operations identified more concerns about quality than did public facilities. Both privately-owned (29%) publicly-owned (17%) operations preferred to adjust their composting process to accommodate changes in feedstock quality rather than rejecting materials that might cause problems, (private 14%, public 4%). Private facilities (14%) were also more likely than publicly-owned facilities (9%) to contact the source of the problem.

Both publicly-owned and privately-owned operations considered their composts to be good quality products. Privately-owned operations generally had a higher opinion of their products (81%) than did publicly-owned operations (68%). The majority of privately-owned (86%) and publicly-owned (57%) operations report they have established markets for their compost products.

Most privately-owned facilities (71%) indicate no difficulty in selling their compost product. Publicly-owned operations had a more varied response: 57% had no difficulty selling their compost, 13% experienced some difficulty, and 13% gave their product away to local residents. Most producers at privately-owned facilities (71%) reported that the cost of production was acceptable, while 39% of publicly-owned facilities reported that the cost of producing their product was low; none reported that it was too high. Producers may have been unsure how to judge their product from a "commercial users point of view" for this question.

All privately-owned and 91% of publicly-owned operators reported there is a demand for their compost product. Most publicly-owned operations sell only one compost product; whereas privately-owned operations are more likely to sell up to four or more products to their clients ($P<0.05$).

Significantly fewer privately-owned operations had an on-site blending process (57%) than publicly-owned operations (13%) ($P<0.05$). On-site bagging facilities were also significantly ($P<0.05$) more common amongst privately-owned (57%) than in publicly-owned facilities (43%).

Most publicly-owned facilities reported relative ease (48%) or some difficulty (44%) in obtaining government approval for a composting facility, whereas, most privately-owned facilities reported some difficulty (57%) or that it was quite difficult (28%) (Fig. 4.7).

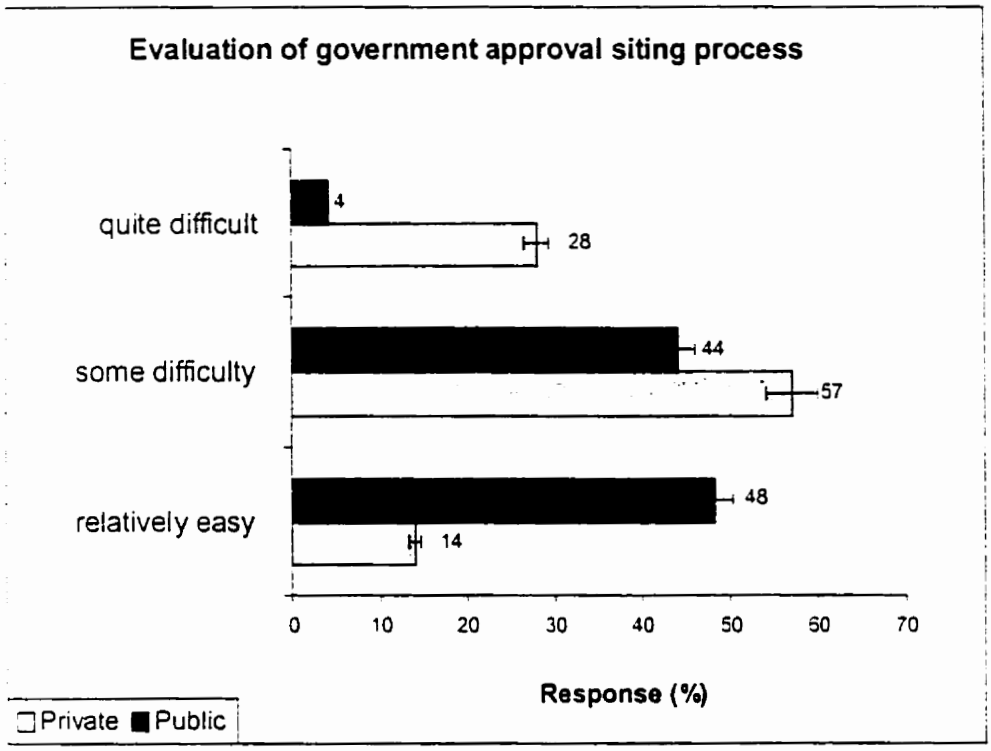


Figure 4.7 Comparison public and private – Evaluation of government approval siting process

More privately-owned than publicly-owned organizations were actively involved in their community. The most common forms of involvement were with gardening and community groups (private 71%, public 30%). Working with local parks was important (public 26%, private 57%) as was working with local food banks (public 17%; private 14%) (Fig. 4.8).

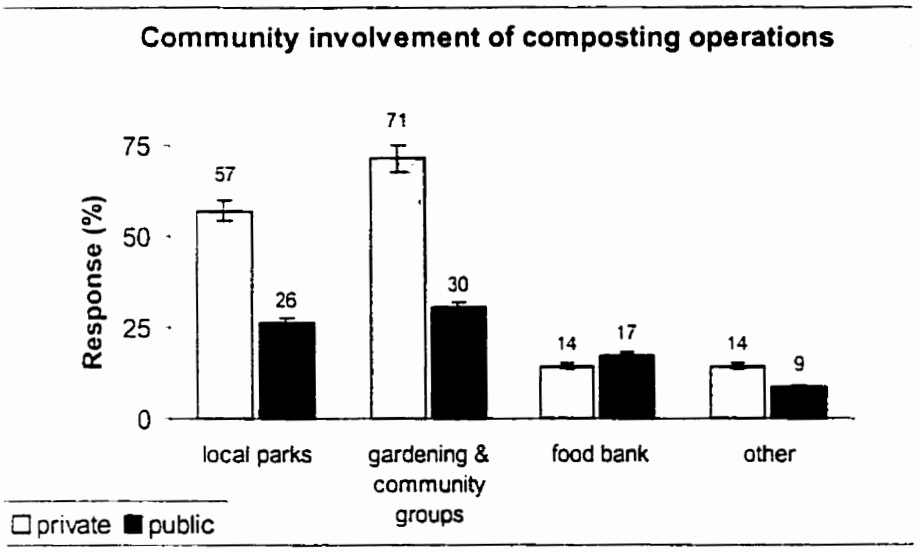


Figure 4.8 Comparison public and private - Community involvement by composting operations.

The major concerns amongst commercial compost producers included developing a good product (private 86%, public 44%) and equipment maintenance (private 57%, public 35%). Funding and generating revenues, were also issues for private (57%) and public (35%) operations. Marketing products and maintaining supply were also important issues for privately-owned (57%) and publicly-owned (30%) operations (Fig. 4.9).

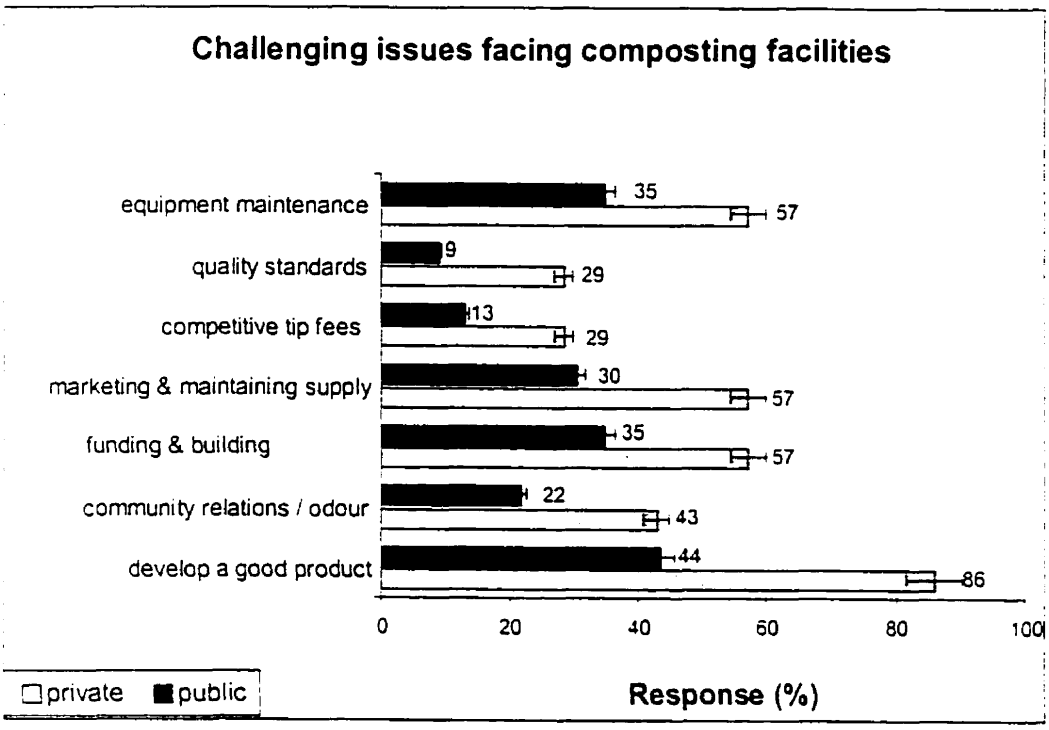


Figure 4.9 Comparison public and private - Challenging issues for composting operations

## 4.2 Users Survey

Sixty-seven percent of compost users preferred to purchase compost in bulk (truckload), while 17% preferred consumer-sized bags. Almost half of respondents (48%) preferred to use blended compost, while 36% preferred pure (non-blended) compost. Less than half (45%) of commercial compost users prepare their own blends, whereas 24% do not blend.

The amount paid for compost products was higher for bagged and blended compost than bulk and pure compost products. Blended compost sold for $\$113/m^3$ whereas bulk blended compost sold for $\$21/m^3$. Users paid considerably less for compost that was not blended ($\$74/m^3$) bagged and ($\$19/m^3$) in bulk. Users of compost were willing to pay less for compost products, only $\$21.59/m^3$ for blended-bagged compost and $\$22.69/m^3$ for bulk blended compost. Users were not willing to pay much for non-blended compost, only $\$15.66/m^3$ for bulk and $\$11/m^3$ for bagged compost.

About half (57%) of respondents reported that the price of compost did not fluctuate at all, 5% indicated seasonal fluctuation. More than half (64%) of users use the compost they purchase on site (use not specified), 26% used it off site, and 26% sold it. Fifty-seven percent reported that a delivery charge was included with the compost purchase. It was found that 45% of compost is produced locally (within 30 km of the buyer). A few participants (17%) apparently did not know where and how far away the compost they were using was produced.

One third (33%) have had problems with the compost they purchased and 12% did not. Although there were problems with compost quality most respondents indicated that they are generally satisfied (79%) with the products they purchased. Problems with compost were addressed by the supplier by asking how the product could be improved without replacing it (14%), supplier would offer to examine the product (10%), or the supplier would examine the product and replace it (7%) .

Although 12% reported they have not had problems with compost they purchased, 24% suggested that the texture and/or blending of the compost could be improved (12%), and that the compost should be weed seed and disease-free (12%) (Fig. 4.10).

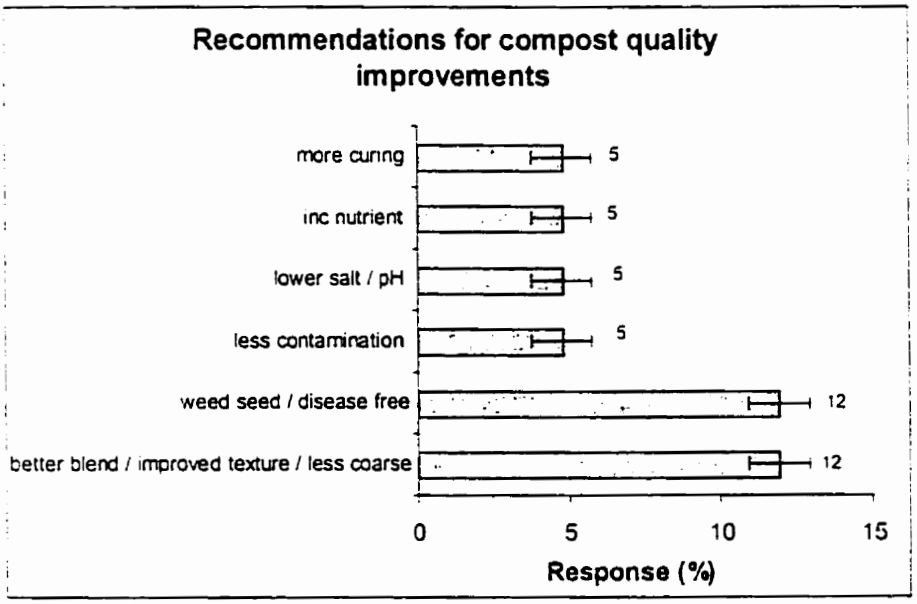


Figure 4.10 User survey – Recommendations for compost quality improvements

Most compost users use compost for a potting mix (64%), others use compost for landscaping and contracting (36%) and one quarter use it for topsoil amendment (Fig. 4.11).

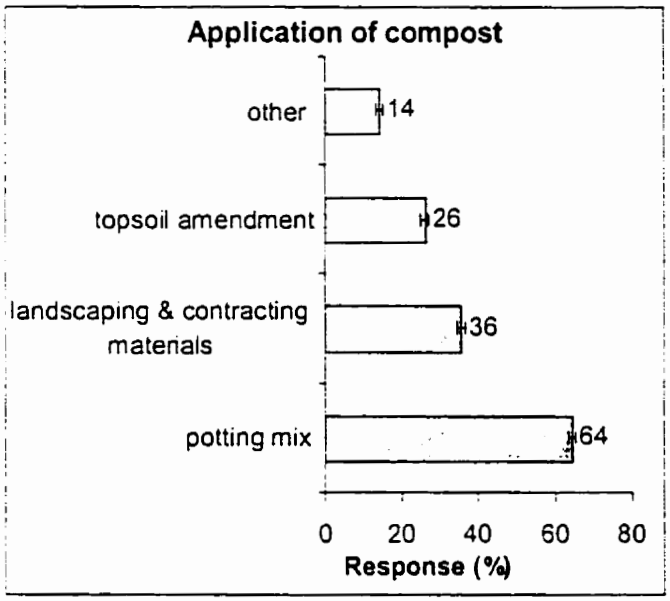


Figure 4.11 User survey – Application of compost

The use of compost has increased over the past five years, complementing the findings in the operator survey where a majority reported that their use of compost has increased slightly (38%) or significantly (33%) (Fig. 4.12).

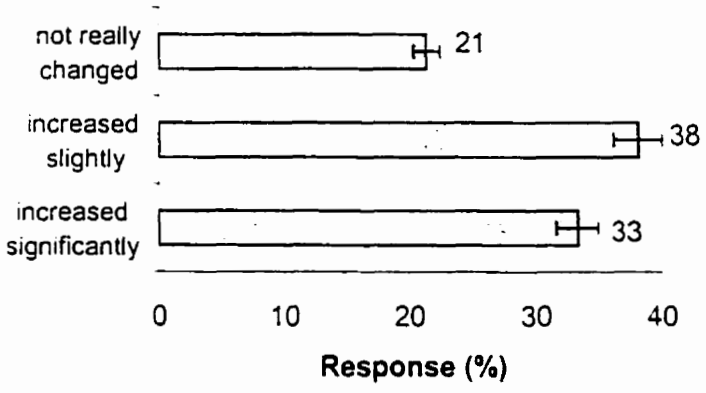


Figure 4.12 User survey - Use of compost over time

Fourty-three percent of compost users surveyed report their use of compost products has grown due to increased knowledge of the benefits of compost (43%) and 19% each reported that their increased use was due to improved quality. Other responses included availability of peat (5%), and recognition of compost as a natural product (7%) (Fig. 4.13).

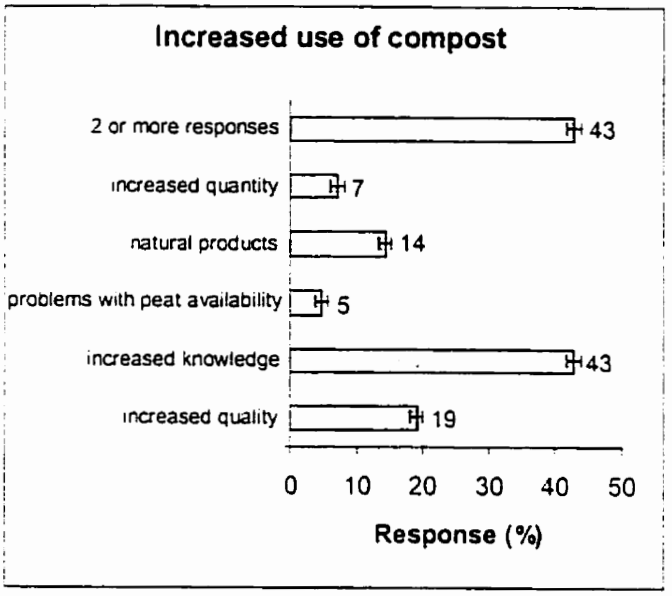


Figure 4.13 User survey – Rationale for increased use of compost products

Most respondents describe themselves as garden centres (60%), nurseries (52%), landscaper/contractors (36%) and topsoil blenders (10%). Thirty-six percent replied to more than one of the above, suggesting that there were different definitions of garden centres and nurseries with these respondents (Fig. 4.14).

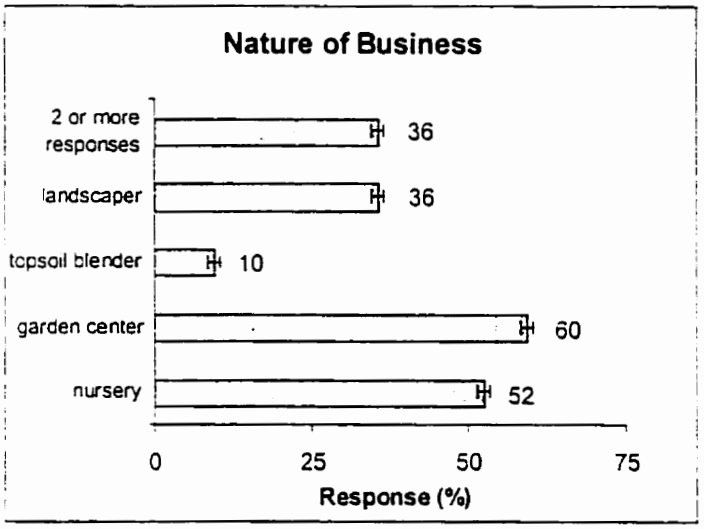


Figure 4.14 User survey – Nature of business

Twenty-six percent of respondents who resell compost reported that 21% of their customers request bagged-blended product and 14% wanted bulk compost-blended product (Fig. 4.15).

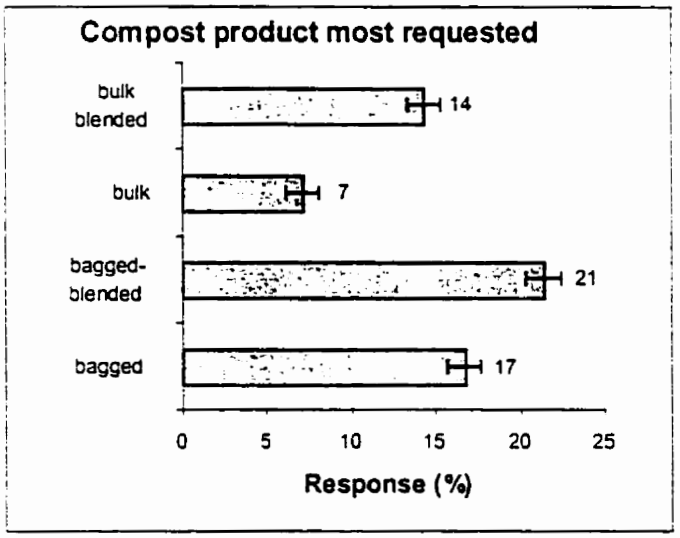


Figure 4.15 User survey – Compost product most requested

Half (48%) of the participants reported that there was a good sense of competition amongst producers, 36% disagreed. Also, half (48%) responded that there were insufficient educational resources available on composting, while 38% reported resources were inadequate.

# 5.0 Discussion

## 5.1 Survey Analysis

The mail survey proved to be a satisfactory method for collecting information about the compost industry in Ontario. It was cost-effective and the application of the method was consistent for all participants. Such consistency may not have been possible through other forms of survey (Nachmias, 1976).

There are limitations to analyzing small data sets. Johnson (1977) cautions that with a small sample size, a substantial, important relationship may not be statistically significant, therefore with small samples we are in danger of dismissing substantial relationships because results may not achieve statistical significance. Kalton (1983) suggests that sampling error can be related to the sample size if the size of the population is too small.

The greater percentage of compost operators (53%) than users (14%) responding to these surveys may be attributed to the greater preparation involved in the operator survey. An Iowa statewide compost market assessment completed in 1998 had a participation rate of 84% (64 out of 74) with composting facilities and 10% (457 out of 4640) of the compost users (Resource Conservation and Development of Northeast Iowa, 1998).

## 5.2 Operational

Ownership (public vs. private) was the main difference amongst the operator survey respondents. The results support those of a 1997 survey by the Composting Council of Canada who found values of 52% publicly-owned and 48% privately-owned (Antler, 1997). The increase may be the result of the increasing presence of private corporations offering waste management services to municipalities. In Ontario, most publicly-owned operations (75%) started after 1990, coinciding with the Ontario government's legislation mandating municipalities to provide composting programs for residential waste during the same time (MOE, 2000).

## 5.3 Composting methods and equipment

The Composting Council of Canada (1999) reported that 40% (138 of 244) of operations across Canada used windrow composting. In this survey, 81% of Ontario operations reported the use of windrow composting (86% private, 78% public). Compared to other types of composting, windrow composting requires more area but it requires less equipment to carry out the process. Invessel systems are the second most common in this survey, 16% overall, 29% private, and 9% public. These technologies compost wastes in a shorter time but involve greater initial overhead costs and require more elaborate operating equipment (Diaz *et al.*, 1994). The equipment required includes a turner (which may be a front-end loader or a dedicated turning machine) and a composting pad with a fabricated drainage system. The most appropriate type of composting system is

largely determined by the individual characteristics of the municipality such as available capital funding, space, and quality and types of feedstock (Diaz *et al.*, 1994).

During interviews, operators often commented on equipment reliability and maintenance. There were no specific concerns about the maintenance of front-end loaders but operators repeatedly reported concerns about windrow turners. Both pieces of equipment are significant investments, costing $100,000 to $250,000 each. If a composting operation depends on a specific piece of equipment, it is essential that it be reliable. The survey did not produce many comments on equipment maintenance, therefore, the assumption can be made that maintenance was not a major concern of compost operators.

## 5.4 Composting feedstock

The types of wastes composted at facilities across Ontario are generally indicative of the variety of organic wastes produced. However, municipal sources such as yard waste and household organics comprise the majority of composted materials. The Composting Council of Canada (Antler, 1999) reports similar practices across Canada; with 53% composting yard waste and 22% composting and food residuals (household organics). In Prince Edward Island and Nova Scotia 54% of sites compost food waste, illustrating that higher organic diversion rates are readily achievable. Sludge is composted at 9% of operations across Canada. This lower rate may be the result of public health and aesthetic perceptions of sludge and because sludge can be directly applied to the land as

a fertilizer or soil conditioner (Chong, 1998).

The survey found that items rejected by publicly-owned composting operations includes grass, yard waste and some non-specified items. Municipal governments often have a separate collection program for yard waste; the volume of these materials is often the reason for this (Barton, 1999). Yard waste typically constitute 13 - 20% of the total municipal waste stream over the year (Clark *et al.*, 1981; Diaz *et al.*, 1993; Glenn, 1989). Grass is occasionally rejected due to the possibility of odour issues (Savage *et al.*, 1994) and the excess nitrogen associated with composting grass clippings (Manser *et al.*, 1996). Privately-owned operations rarely rejected waste materials, as is evident in the diversity of items they compost (BioCycle, 1994c). In this survey, operators report a considerable amount of contamination problems arose from municipal sources, predominately plastics, and other household items. Possibly household organic wastes should be composted at home; this could also serve as a means to educating the public at home by creating awareness and responsibility.

Privately-owned facilities experienced problems with contamination originating from household sources. At the City of Guelph's Wet-Dry Recycling Centre a trommel screen and a magnet help to reduce contamination and ensure consistent quality of organic waste entering the invessel system. Less technical composting facilities may experience more frustrations with contamination if they do not have the resources or equipment to screen incoming feedstock.

A small percentage of publicly-owned facilities indicated concerns with high levels of salts, metals and oils (4%). These types of contamination may be

the result of less education to residents regarding the requirements for quality feedstock coming into the facility. Most often, the contaminated materials are those of municipal origin.

A pilot program in Olds, Alberta exhibited notable problems with contamination in a residential waste stream. One solution might be to compost household organic wastes at home; this could also serve as a way of creating awareness and responsibility as well as educating the public at home as a form of hands on learning. Ontario has been a leader of backyard composting in North America thanks to comprehensive education programs and government subsidies for composters (BioCycle, 1994a). There are ways of encouraging household participation and improving the quality of materials from these sources. For example, Baere *et al.* (1992) found that adding newspaper up to 50% by volume would yield a compostable waste stream, which improved compose quality while reducing odour problems and runoff.

Most operators reported that they can manage the combination of waste materials they currently compost, and if different wastes are accepted it is not difficult to adapt their process to incorporate these new materials. Farrell (1996) encourages constant experimentation and observation of feedstock, equipment and composting methods. Producing quality product is dependent on the quality of feedstock as well as being able to find the right balance of materials and nutrients (van der Werf, 1995).

## 5.5 Odour management

Composting operations are generally perceived to be odoriferous places. Most facilities I visited did not, however, produce excessive odours. The most odorous areas were the active (invessel) areas of the system, or the tipping areas (where feedstock is off-loaded). Most facilities reported that odours were not an operational issue. To minimize odours most operators turned windrows when there was no wind and kept doors at invessel facilities closed; fresh feedstock was also immediately covered (BioCycle, 1994b). Mechanisms for preventing and managing odour issues include: identifying the source of the problem (outlining problems and issues); developing a community relations program, and; implementing a plan before outside sources can react to the problem (Chapple 2000; Goodwin, 2000; Goldstein, 1996; Goff, 1999; Hunt, 1990).

Biofilters are an effective way of treating odours from invessel systems (BioCycle, 1994; Savage *et al.*, 1994). Organic mixtures of essential oils can also be used in misting systems to modify, mask or neutralize offensive odours (Chapple, 1998). Odour control could benefit from operations being proactive (i.e. good community relations).

## 5.6 Facility siting and community involvement

The siting of operations and community reactions to the facility has generally been a positive experience for operators. Approval for siting was easy to obtain for more than half of both the privately and publicly-owned operators, a

few reported that the process was difficult. The proximity of composting operations to landfill sites affected tipping fees by encouraging the separation of organics. Both publicly-owned and privately-owned composting facilities charged less (or perhaps nothing) to dump organic materials, landfills benefit from this diversion of organic material by extending their life span. Close proximity of a composting facility to a landfill also means substantially lower transportation costs for the public and the waste management facilities operators (Savage, *et al.*, 1994).

Both publicly-owned and privately-owned operations are commonly involved in community activities, such as gardening, community groups, and local parks. This type of involvement is a form of "free" advertising for some composting facilities. Each year the City of Guelph provides a portion of its compost to local schools and Scouts groups who in turn sell the product to the public as a fund-raiser (Barton pers com., 1999). Participation in programs such as Communities in Bloom (CIB) promotes a connection to the importance of the product for horticultural uses and targets a specific market where value added products might be easily marketed (Barton, 1999). Communities in Bloom is an independent, non-profit program promoting environmental awareness and municipal beautification. CIB is an initiative designed in 1995 to involve whole communities in the challenge of improving the visual appeal of Canada's cities, towns and villages and to compete for provincial and national awards, (CIB, 2000

## 5.7 Economic

Composting operations, like other businesses, must be both economically viable and environmentally sustainable. They must produce a quality marketable product while continuously dealing with operational issues. Most publicly-owned operations have grown substantially (65%), while the majority (43%) of privately-owned facilities reported slow growth. In this study, 9% of operations reported revenues to be greater than expenses, the majority reported expenses and revenues to be equal. Operations are growing, yet their revenues do not often exceed their expenses. Economic statements are generated in different ways and accounting practices can affect financial statements. An example in Ontario composting community led to the closure of TCR Environmental Corp in southwestern Ontario. Mis-reporting of diversion data and promises to investors led to the closing of the company (Crittenden, 2000).

Publicly-owned facilities may have more physical and financial resources, including landfill sites and other departments within the municipality. In particular, the availability of tax resources makes public composting facilities more financially stable. The Wet Dry Materials Recovery Facility in the City of Guelph had a $25 million overhead cost. It is important to note that considerable portions of these costs were funded by government grants, and that other facilities may not require such a high capital cost to accomplish comparable results (Diaz *et al.*, 1994). Extensive revenues in the waste management industry are not common; therefore, large capital investments are unusual. Renkow *et al.* (1994) states that economies of scale favor more sophisticated

systems at larger annual volumes whereas lower annual volumes with specialized equipment are not likely to be cost effective.

For a privately-owned run facility to be financially secure, it is often common to have more than one line of business (Johnson, 1998). Common partnerships may include nursery or horticultural operations, landscaping, and hauling. A family farm in Colorado began composting its own waste in 1973 and now markets over 390,000 $m^3$ of compost annually; it is one of the largest composting operations in the State (Johnson, 1998).

Tip fees charged by public ($20.36/tonne) and privately-owned ($23.57/tonne) operations in Ontario were not significantly different. The national average of tip fees at composting operations was $26/tonne (Antler, 1997). According to the results of this survey, waste generators can expect to pay much less in tip fees for organic materials at a composting site as compared to a landfill site, from no fee at all to 1/3 less.

The funds received before set up and during current operations was slightly greater for the privately-owned facilities than the publicly-owned operations ($P < 0.05\%$). There was a tendency among public respondents to ignore questions on funding, yet slightly more respondents had received funding at a previous time (38%), and slightly less are currently receiving funding (34%). This corresponds with decreased government spending in the MOE and OMAFRA since 1991 when most composting operations were initiated (Table 5.1).

Table 5.1 Comparison private and public - political powers and spending

| Time | Party in Power | *Operations conceived* | *Operations Started* | Spending (MCE, OMFRA) $ (millions) | | |
|---|---|---|---|---|---|---|
| Pre 1987 | PC & Liberal | *29%* | *22%* | Not Available | | |
| 1987 – 90 | NDP | | | | | |
| 1991 – 95 | PC | *59%* | *75%* | 1991/92 | 460 | 605 |
| 1996 – 99 | PC | | | 1996/97 | 365 | 452 |
| | | | | 1998/99 | 270 | 295 |

(Brenda Chanberlin's office, pers. com., 1999)

The cost of compost production per tonne varied due to size of operations, composting methods, overhead, etc. For a relatively large volume invessel system, costs may be as high as $70/tonne (Barton pers. com., 1999). Smaller, less complicated invessel operations may be able to operate at a production cost of $30-40 per tonne (van der Werf, 1999). The difference between these two examples is dependent on factors such as: the size of the facility and the types of equipment used, as well as the extent to which the organic materials are composted (Diaz, 1994). The second operation is able to sell its product before it is cured, which eliminates the need for additional space and time for monitoring (van der Werf, 1999).

Costs in the United States have been reported as low as $3 US per tonne, this figure from a combined landfill/composting state-owned operation in the mid west (Resource Conservation and Development of Northeast Iowa, 1998).

## 5.8 Marketing

The average price of compost in bulk form is \$19 $m^3$ for pure compost and \$21$m^3$ for blended compost. When asked what they would prefer to pay, the responses were varied \$15.66 $m^3$ for pure compost and \$22.69 $m^3$ for blended compost, perhaps indicating that users are willing to pay more for blended products. Chong (1998) suggests that some users are only willing to pay \$11 $m^3$. Most compost producers indicated that the cost of their compost was acceptable or low from a point of view of a producer. The most common type of compost preferred by compost users was bulk compost, which is the least expensive to produce.

Selling compost is generally not an issue for compost operators, as only 18% had a concern. Privately-owned operations must sell their product as they are economically motivated (BioCycle, 1994d). Publicly-owned operations are less profit-oriented, not always motivated to sell compost products - rather they are obligated to divert waste from landfill and provide a service to ratepayers. The privately-owned operators therefore consistently work towards developing a competitive marketable quality product. However, Alexander (1998) suggests that it is the publicly-owned larger facilities that have more resources to invest in marketing their product. Successful compost marketing requires a consistent supply and variety of quality products combined with good customer service (Albrecht, 1989).

Compost use has generally increased, attributable in part to increased knowledge of the benefits of compost and increasing quality of the product (Lasoff, 2000; Savage *et al.*, 1994). In the future, it is reasonable to expect sales to continue to increase. The average amount of compost used by commercial compost users surveyed in Ontario is 1000 $m^3$ of pure compost and 3500 $m^3$ of blended compost.

The agricultural sector is a substantial user of compost and demands a good quality product at a reasonable cost (Corti, 1998; Lasoff, 2000).

Most operators rated their compost product as "good" for use as a soil conditioner, amendment or fertilizer, and blending materials. Privately-owned composting operations generally had a higher opinion about the quality of their products, the average rating of "good" amongst privately-owned operators was 81% vs. 68% for publicly-owned operations. This may be indicative of more interactions with customers for the development of specific compost products (Segall *et al.*, 1990). Compost operators can use a rudimentary on-site laboratory to provide similar results to that of a professional laboratory for monitoring the quality of their own products (van der Werf *et al.*, 1987).

Most compost users preferred buying bulk compost; blended compost was also used, but its use depended on the blending ratio. Many operators did not have bagging facilities or blending facilities, suggesting a need for a variety of blending ratios that may be better determined by the user. For the most part, operators and users seem to agree on quality compost with retailers and independent distributors.

In addition to developing a good compost product, value-added features such as screening, blending and bagging help make products more marketable (Albrecht, 1989). Almost half of privately-owned facilities have blending facilities in contrast to the publicly-owned facilities that had few. Similarly, significantly more privately-owned (57%) owned facilities than publicly-owned (4%) enhanced their marketing efforts to give the a market advantage by bagging and produced a variety of products ($P < 0.05$). Bagging compost expands markets and can be more popular than bulk sales, thereby creating an important revenue source (Steuteville, 1996).

Compost users indicated the various uses of ratios of compost blends, most blended their own for potting mixes. One quarter used compost as topsoil fill amendment, a blending oriented use for compost. The most common method suggested for improving compost products was better blending. Alexander (1994) states that compost blends have a greater potential in the market place. The increased use of compost was largely attributed to an increased knowledge of the benefits of compost. Continued public awareness and education have a positive effect on the industry (Segall *et al.*, 1990).

Most users of compost were satisfied with the compost they purchased a response that encompasses both the service and the quality of the product. These results reflect the efforts of compost operators to ensure customer satisfaction. However, compost operators must also consider that high-end markets such as nurseries require top-quality compost (Chong, 1996b). Most compost users reported there was a sense of competition amongst producers,

therefore increased competition should result in higher quality composts and more competitively priced products (Alexander, 1998). Composting operations should (1) retain a stable market for a major product, (2) maintain control of the waste stream and (3) maintain a good economic operation (Clark *et al.*, 1981). These factors provide a solid foundation for successful composting operations.

# 6.0 Conclusions and Recommendations

## 6.1 Conclusions

Factors that may be limiting the production of compost in Ontario include:

- Concerns from compost operators with producing quality products, maintaining market supplies, and building revenues.
- Privately-owned operations appear to be more committed to their need to produce a variety of quality value-added products as well as maintaining competitive in the market than publically-owned operations.
- Privately-owned composting operations reported more difficulties during government site approval processes while establishing their operations.

Factors that may be limiting the utilization of compost in Ontario include:

- Compost is most commonly purchased in pure bulk form but is often amended (blended) before the end use indicating an intermediate .
- Compost users are requesting better blended, weed seed and disease free compost products however they are not willing to pay more for their compost.
- Compost use and knowledge its benefits are increasing however only 25% of organic materials are being composted.

## 6.2 Recommendations

- Compost producers should strive to meet the needs of compost users and provide consistent high quality products at an equitable cost. There are many user applications for compost (agriculture, nurseries, landscaping, and land reclamation) and there is demand for high-end products.
- Compost producers could benefit from pursuing a rigorous marketing strategy including product research, promotion, education, sales, and distribution.
- Composting facilities should continue to be involved in community projects. The benefits of this are intangible and they add to the positive perception of the operation and the composting industry as a whole.
- Similar surveys should be conducted in other provinces would be beneficial. A survey to the public on compost production and compost use would benefit the operations and users that have participated in this survey. Knowledge of the end users expectations is important.

# References


Adani, F., Genevini, P., Gasperi, F., and Zorzi, G. 1997. Organic matter evolution index (OMEI) as a measure of composting efficiency. Compost Science and Utilization. 5(2): 53-62.

Albrecht, R. 1989. How to succeed in compost marketing *in The BioCycle guide to composting municipal wastes.* JG Press, Emmaus. 195pp.

Alexander, R. 1998. Five steps to successful compost marketing. BioCycle 39(6): 63-64.

Antler, S. 1996. Expanding the market for compost in Canada. Recycling Product News July/August: 3.

Antler, S. 1997. Canadian compost standards. BioCycle. 38(4): 94

Antler, S. 1999. Composting grows stronger. Solid Waste and Recycling. June/July issue: 10–13.

Antler, S. 2000. Canadian composting industry on the grow. BioCycle. 41(3): 41

Ashton Statistical Laboratory. 2000. University of Guelph. Personal Communications.

Baere, L., Six, W., Tillinger, R., Verstraete, W. 1992. Wastepaper improves biowaste composting. BioCycle 33(9): 70-71.

Babbie, E. 1995. Practicing social research, 7th ed. Wadsworth Publishing Company, New York. 474pp.

Barth, J., and Kroeger, B. 1998. Marketing compost in Europe. BioCycle. 39(10): 77

Barton, Trevor. 1999. Marketing Officer, Solid Waste Services, City of Guelph. Personal communications.

Barkdoll, A., and Nordstedt, R. 1994. Comparison of composting systems *in Composting source separated organics.* JG Press, Emmaus. 286pp.

Belton, V., Crowe, D., Matthews, R., and Scott, S. 1994. A survey of public attitudesto recycling in glasgow (u.k.). Waste Management and Research. 8:351-367.

BioCycle. 1994a. Home composting programs *in Composting source separated organics*. JG Press, Emmaus. 286pp.

BioCycle. 1994b. Odor control at composting sites *in Composting source separated organics*. JG Press, Emmaus. 286pp.

BioCycle. 1994b. Minimizing waste, maximizing recycling *in Composting source separated organics*. JG Press, Emmaus. 286pp.

BioCycle, 1994d. No tipping fees at this diversified compost site *in Composting source separated organics*. JG Press, Emmaus. 286pp.

Block, D. 1997. Disease suppression on the links. BioCycle. 38(10): 62.

Block, D. 1998. Municipal composter pioneers in the "show me" state. BioCycle. 39(4): 48.

Block, D. 1998. The Kansas route into the composting business. BioCycle. 39(4): 50.

Bureau de Normalization du Quebec. 1996. Support document for compost quality criteria. Centre de recherche industrielle du Québec. 33pp.

Bradley, J., Kohllepel, T., Waliczek, T., and Zajicek, J. 2000. Factors affecting recruitment of horticulture students at major universities. HorTechnology 10(3): 631-636.

Canadian Council for Ministers of the Environment (CCME), Composting Subcommittee 1996. Guidelines for compost quality. CCME 106E. Canadian Council of Ministers of the Environment. Winnipeg, MB. 25pp.

Canadian Institute for Environmental Law and Policy (CIELAP). 1992. Looking back and looking ahead, municipal solid waste management in Ontario. CIELAP, Toronto. 68pp.

Canadian Institute for Environmental Law and Policy (CIELAP). 1997. Recent developments in waste management in Canada. CIELAP, Toronto. 22pp.

Chanberlin, B. 1999. Guelph MPP, personal communications.

Chapple, P. 1998. A neutralizing system for odour control. Solid Waste Technologies. March/April Issue: 46-47.

Chapple, P. 2000. Be proactive - develop an odour prevention plan. Canadian Environmental Protection 12(3): 10.

Chong, C. 1995. Compost! Compost! What to do with it. Landscape Trades 17(6): 29-31.

Chong, C. 1996a. Composting basics practical considerations. Landscape Trades 18(4): 20-47.

Chong, C. 1996b. Myths about compost. Horticultural Review 14(10): 30.

Chong, C. 1998. Experiences with the utilization of wastes in nursery potting mixes as field soil amendments. Canadian Journal of Plant Science 79: 139-148.

Clark, R. and Gillean, J. 1981. Resource recovery planning and management. Ann Arbor Science Publishers Inc., Michigan. 167pp.

Communities in Bloom (CIB). 2000. www.pitch-in.ca

Composing Council of Canada. 1997. Setting the standard: A summary of compost standards in Canada. Pamphlet

Corti, C. 1998. Compost use in plant nurseries: hydrological and physiochemical characteristics. Compost Science and Utilization 6(1): 35-45.

Criner, G., Kezsis, A., White, G., and O'Connor, J. 1996. Regional composting of residential waste: an economic analysis. Compost Science and Utilization. 3(4) 31-39.

Crittenden, G. 2000. Hot-wiring Strathroy. Solid Waste and Recycling. December/January Issue: 8-10.

Davis, G., and Kitto, S. 2000. Industry inspection: a survey of eastern North American native plant nurseries reveals problems with plant production and cultivation. American Nurseryman 191(4): 111-115.

de Vaus, R.A. 1986. Surveys in social research. George Allen and Uwin, Sydney. 276pp.

Diaz, L., Savage, G., and Golueke, C. 1982. Resource recovery from municipal solid wastes. CRC Press Inc, Boca Raton. 178pp.

Diaz, L., Savage, G., Eggerth, L., and Golueke, C. 1993. Composting and recycling municipal solid waste. Lewis Publishers, Boca Raton. 296pp.

Diaz, L., Savage, G. M. and Golueke, C. G. 1994. Composting of municipal solid wastes. *in* Kreith, R. Handbook of solid waste management. Section 10. McGraw-Hill Inc., New York. 1165pp.

DiGiovanni, T. 1998. Executive Director of Landscape Ontario. Personal communication.

Dillman, D. 1978. Mail and telephone surveys, the total design method. Whiley, Toronto. 235pp.

Dolan, A., Kreutzwiser, R., and de Loe, R. 2000. Rural water use and conservation in southwestern Ontario. Journal of Soil and Water Conservation. 55: 161-171.

Farrell, B. 1996. Keeping it simple ... and manageable. BioCycle. 37(2): 58.

Fitzsimons, J. 1998. Application of quantitative techniques in rural planning and development version 5.0. 60pp.

Fowler, F. 1984. Survey research methods. Sage Publications, Beverly Hills. 159pp.

Fauci, M., Bezdicek, D., Caldwell, D. and Finch, R. 1999. End product quality and agronomic performance of compost. Compost Science and Utilization. 7(2): 17-29.

Folliet-Hoyte, N. 1996. Canadian national compost standards. *in Bertoldi, D., Sequi, P., Lemmes, B., and Tiziano, P. The science of composting.* Blackie Academic and Professional, London. 672pp.

Glenn, J. 1989. Yard waste utilization *in the BioCycle guide to composting municipal wastes.* JG Press, Emmaus. 196pp.

Goff, K. 1999. Controlling odors at compost facilities. Municipal Solid Waste Management. July/August: 64-69.

Goldstein, N. 1996. Odour control experiences: lessons from the biofilter. BioCycle. 37(4): 70.

Golueke. C. 1972. Composting A study of the process and its principles. 321pp.

Golueke, C. 1989. A rationale for composting *in the BioCycle guide to composting municipal wastes.* JG Press, Emmaus. 196pp.

Golueke, C. 1994. Implementing Principles *in Composting source separated organics*. JG Press, Emmaus. 286pp.

Goodwin, J., Amenta, S., Delo, R., Del Vecchio, M., Pinnette, J., and Pytlar, T. 2000. Odor control advances at composting facility. Biocycle p68. www.jgpress.com/bc%20articles/2000/01/0005/01005.html

Gotaas, H. 1956. Composting sanitary disposal and reclamation of organic wastes. World Health Organization, Geneva, Switzerland. 205pp.

Gouin, F. 1994. Standards for horticultural Industries *in composting source separated organics*. JG Press, Emmaus. 286pp.

Gouin, F. 1998. Using compost in the ornamental horticultural industry *in Brown, S., Angle, S., and Jacobs., eds. Beneficial co-utilization of agricultural, municipal and industrial by-products*. Kluwer Academic Publishers, Boston. 430pp.

Halet, G., Otten, L., Winter, J., and Voroney, P. 1996. Environmental evaluation of composting process and compost quality. University of Guelph. 206pp.

Haug, R. 1980. Compost engineering: principles and practice. Ann Arbor Science, Michigan. 247p.

Heinen, J. 1995. A review of, and research suggestions for, solid waste management issues: the predicted role of incentives in promoting conservation behaviour. Environmental Conservation. 22(2)157-166.

Hoitink, J., Keener, H., and Krause, C. 1994. Management Principles *in Composting source separated organics*. JG Press, Emmaus. 286pp.

Hughes, E. 1980. The composting of municipal wastes. *in*: Bewick. Handbook of organic waste conversion. pp108-134. Van Nostrand Reinhold Ltd., New York. 419pp.

Hunt, P. 1990. Communications and odor control. BioCycle 31(1):43-45

Jackson, W. 1988. Research methods, rules for survey design and analysis. Prentice-Hall, Scarborough, Ontario. 290pp.

Johnson, A. 1977. Social statistics without tears. McGraw-Hill Inc., New York. 270pp.

Johnson, K. 1998. Balancing markets with compost production. BioCycle. 39(6):48-50.

Joosse, P. 1992. Recycling of organic resources in production agriculture. Soil and Water Conservation Information Bureau, University of Guelph. 198pp.

Kalton, G. 1983. Introduction to survey sampling. Sage Publications, Beverly Hills. 96pp.

Kitto, D. 1988. Composting the organic natural way. Thorsons Publishing Group, England. 128pp.

Lasoff, M. 2000. Growing compost profits. Waste Age. (31(8):44-53.

Manser, A., and Keeling, A. 1996. Practical handbook of processing and recycling municipal waste. Lewis Publishers, New York. 557pp.

Martegani, A. 1985. Machinery aspects of compost making. *in composting of agricultural and other wastes, Gasser, J. ed. Elsevier Applied Science Publishers, London. 320pp.*

May, J., Simpson, T., and Relf, D. 1994. Potential utilization of yardwaste compost in Virginia: a survey of nursery operators. HortTechnology 4(3):288-290.

Mendenhall, W. and Beaver, R. 1994. Introduction to probability and statistics. Duxbury Press, California. 689pp.

McGauhey, P. 1971. American composting concepts. United States Environmental Protection Agency, Washington. 57pp.

Ministry of the Environment (MOE). May 1990. Composting: a literature study. 154pp.

Ministry of the Environment (MOE). October 1991. Regulatory measures to achieve Ontario's waste reduction targets. 30pp.

Ministry of the Environment (MOE). November 1991. Interim guidelines for the production and use of aerobic compost in Ontario. Publication No. PIBS 1749. Queen's Printer for Ontario, Toronto, Ontario. 27pp.

Ministry of the Environment (MOE). 1993. Environment information – Ontario's new 3R's regulations: backgrounder. 11pp.

Ministry of the Environment (MOE). 1998. Draft guidelines for aerobic composting facilities and compost use. 27pp.

Ministry of the Environment (MOE). 2000. Fact sheet 1999, WDO municipal 3R's Ontario. Queens Printer for Ontario, Toronto. 6pp.

Nachmias, D. and Nachmias, C. 1976. Research methods in the social sciences. St. Martin's Press, New York. 335pp.

Nelson, S., Dinel, H., and Goodyear, T. 1995. A program to asses the impacts and benefits of composted source-separated solid wastes (CSSSW) applied to agricultural lands: national agricultural trial technical bulletin 1995-9E. Cartographic Design and Reproduction Unit, Centre for land and biological resources research, Ottawa. 93pp.

Norusis, M. 1997. SPSS 6.1 guide to data analysis. Prentice-Hall, New Jersey. 582pp.

Ontario Government. 1993. Bill 7 An act to amend certain acts related to municipalities concerning waste management. Royal Assent October 26th, 1993. 21p.

Pinamonti, F., and Zorzi, G. 1996. Experiences of compost use in agricultural and in land reclamation projects. *in Bertoldi, d., Sequi, P., Lemmes, B., and Tiziano, P. The science of composting.* Blackie Academic and Professional, London. 672pp.

Platt, B., Doherty, C., Broughton, A., and Morris, D. 1991. Beyond 40% record-setting recycling and composting programs. Island Press, Washington D.C. 264pp.

Polprasert, C. 1996. Organic waste recycling technology and management. John Wiley and Sons, New York. 412pp.

Pope, Bruce. 2000. Personal conversations. Waste Management Analyst Waste Management Policy Branch Ministry of the Environment.

Rea, L. and Parker, R. 1997. Designing and conducting survey research. Jossey-Bass Publishers, San Francisco. 254pp.

Renkow, M., Safley, C., and Chaffin, J. 1993. A cost analysis of municipal yard waste composting *in composting source separated organics.* JG Press, Emmaus. 286pp.

Resource Conservation and Development of Northeast Iowa. 1998. Iowa statewide compost market assessment. Iowa Department of Natural Resources, Iowa. 70pp.

Richard, T. 1990. Clean compost production. BioCycle 31(2):46-47.

Roulston, L. 2000. In-vessel composting of residential organics. BioCycle 41(1):32-34.

Rowntree, D. 1981. Statistics without tears. Penguin Books, England. 199pp.

Savage, G., and Diaz, L. 1994. Avoiding problems in siting and processing *in composting source separated organics.* JG Press, Emmaus. 286pp.

Segall, L., and Alpert, J. 1990. Compost marketing strategy. BioCycle 31(2)38-43.

Shiralipour, A., McConnell, D., and Smith, W. 1994. Applying compost to crops *in composting source separated organics.* JG Press, Emmaus. 286pp.

Shiralipour, A., Philip, B., Portier, K. 1996. Using compost products in vegetable production *in Brown, S., Angle, S., and Jacobs., eds. Beneficial co-utilization of agricultural, municipal and industrial by-products.* Kluwer Academic Publishers, Boston. 430pp.

Sikora, L. 1998. Effect of compost – fertilizer blends on crop growth *in Bertoldi, d., Sequi, P., Lemmes, B., and Tiziano, P. The science of composting.* Blackie Academic and Professional, London. 672pp.

Snedecor, G. and Cochran, W. 1989. Statistical methods, 8th ed. Iowa state University Press, Ames. 503pp.

Steel, R. and Torrie, J. 1980. Principles and procedures of statistics, 2nd ed. McGraw-Hill Book Company, New York. 633pp.

Steuteville, R. 1996. The bottom line in bagging. BioCycle 37(8): 62-63.

Stoklas, U. 1999. Applied research scientist. Composting Technology Centre, Olds College, Alberta. Personal Communications.

SPSS. 1997. Statistical package for the social sciences 8.0. SPSS Inc., Chicago.

United States Environmental Protections Agency (USEPA). 1994. Waste prevention, recycling, and composting options. US Government Printing Office. 168pp.

van der Werf, P. 1995. Processing materials from a wet/dry collection. BioCycle 36(1): 58-60.

van der Werf, P. and Ormseth, J. 1987. Measuring process parameters at an enclosed composting facility. Biocycle 38(5): 58.

van der Werf. P. 1999. Compost Operator, Greenlane Environmental. Personal communications.

Walker, J., Goldstein, N., and Chen, B. 1989. Evaluating the in-vessel composting option *in the BioCycle guide to composting municipal wastes.* JG Press, Emmaus. 196pp.

## Appendix A

Operator survey

# Survey of Composting Operations in Ontario

*Confidence intervals are significant to 95% based on the normal approximation to the binomial distribution.*

1. What is your position within this composting facility?

θ owner
θ manager
θ technician
θ other _____
θ operator
θ labourer

| Respondent's position | Private (%) | Public (%) |
|---|---|---|
| Owner | 43 ± 9 | - |
| Manager | 57 ± 9 | 78 ± 2 |
| Technician/operator/labourer | - | 9 ± 1 |
| Waste management coordinator | - | 9 ± 1 |

2. Choose the type of ownership of this composting operation/ company.

θ public
θ combination of ownership's
θ private

| Ownership | Response (%) |
|---|---|
| Public | 69 ± 2 |
| Private | 22 ± 1 |
| Combination | 9 ± 1 |

3. How many employees at this site?

| Mean number of Employees | Private | Public |
|---|---|---|
| Full-time | 15 | 2 |
| Part-time | 4 | 3 |
| Summer | 5 | 2 |
| Winter | 4 | 2 |

4. When was this composting operation first conceived?

   Please provide month and year: _____

5. When did this site first start processing organic waste?

   Please provide month and year: _____

| Time | Q 4 Idea | | Q 5 Start | |
|---|---|---|---|---|
| | Private % | Public % | Private % | Public % |
| Pre 1980 | 14 ± 4 | - | 14 ± 4 | - |
| 1980 – 1989 | - | 22 ± 1 | - | 9 ± 1 |
| 1990 – 1998 | 86 ± 4 | 63 ± 3 | 86 ± 4 | 83 ± 2 |

| Time from idea to start-up | Private (%) | Public (%) |
|---|---|---|
| < 1 year | 29 ± 7 | 43 ± 9 |
| > 1 # 2 years | 14 ± 4 | 22 ± 6 |
| > 2 years | 57 ± 9 | 13 ± 4 |

6. In this operation do

θ revenues exceed expenses
θ expenses exceed revenues
θ revenues generally equal expenses

| Expenses vs. revenues | Private (%) | Public (%) |
|---|---|---|
| Expenses > revenues | 14 ± 4 | 9 ± 3 |
| Expenses = revenues | 43 ± 9 | 70 ± 2 |
| Expenses < revenues | 29 ± 8 | 17 ± 2 |

7. Since this operation first started, has this business

θ grown substantially
θ grown slowly
θ not changed a great deal (we have had ups and downs)
θ been challenging
θ experienced great difficulty staying alive

| Growth of composting Operation | Private (%) | Public (%) |
|---|---|---|
| Substantial | 14 ± 4 | 65 ± 2 |
| No change | 14 ± 4 | 13 ± 1 |
| Slow | 43 ± 9 | 17 ± 1 |
| Challenging | 14 ± 4 | 4 ± 0 |

8. Is this site located in close proximity to or adjacent to a landfill site (that accepts compostable materials)?
   θ yes θ no

| Distance from Landfill site | Private (%) | Public (%) |
|---|---|---|
| Close | 71 ± 3 | 61 ± 2 |
| Not close | 29 ± 7 | 39 ± 2 |

9. Please provide the tip fee of the closest landfill site to your composting operation. Fee should reflect the cost of disposing organic materials.

Please provide the tip fee at this composting site. Please provide all fees if more than one apply at this site.

| Tip Fee ($) | Average ($) | | Highest ($) | | Lowest ($) | |
|---|---|---|---|---|---|---|
| | Private | Public | Private | Public | Private | Public |
| Landfill | 52 | 64 | 90 | 120 | 20 | 30 |
| Compost site | 29 | 23 | 60 | 70 | 0 | 0 |

10. Is there external financial support of this operation at the current time? If you have no external funding, proceed to Q. 11.

11. If there is no current external funding, was there any external funding available to the operation at a previous time (i.e. during start up or with purchase of new equipment)?

| Funding Received | Yes (%) | |
|---|---|---|
| | Private | Public |
| Q 10 Previously | 29 ± 7 | 30 ± 2 |
| Q 11 Currently | 14 ± 4 | 35 ± 2 |

12. Method of composting at your site. Please provide details where possible.

θ windrow – outdoor
θ static pile - outdoor (PAWS)
θ invessel - (aeration & turning)
θ combination of technologies _____
θ other _____
θ windrow – indoor
θ static pile – indoor (PAWS)
θ sealed container (i.e. Herhoff)

| Method of composting | Private (%) | Public (%) |
|---|---|---|
| Indoor windrow | 57 ± 9 | 87 ±1 |
| Outdoor windrow | 86 ± 4 | 78 ± 2 |
| Indoor static pile | 29 ± 7 | 26 ± 2 |
| Outdoor static pile | 57 ± 9 | 17 ± 1 |
| Invessel | 29 ± 7 | 9 ± 1 |
| Sealed container | 43 ± 9 | 4 ± 0 |

13. What types of organic wastes are composted in this operation? (check all that apply).

θ municipal yard waste
θ leaves
θ agricultural wastes
θ municipal sludge
θ granary wastes
θ other _____
θ grass
θ household organics
θ paper sludge
θ animal wastes
θ industrial wastes (specific)

| Types of waste composted | Private (%) | Public (%) |
|---|---|---|
| Municipal yard waste (no grass) | 86 ± 4 | 87 ± 1 |
| Municipal yard waste & grass | 86 ± 4 | 78 ± 2 |
| Municipal yard waste & household organics | 29 ± 7 | 26 ± 2 |
| agricultural wastes | 57 ± 9 | 22 ± 2 |
| Sludge | 71 ± 3 | 9 ± 1 |
| Industrial organic waste | 43 ± 9 | 22 ± 2 |
| Wood | - | 4 ± 0 |

14. What is the average annual volume of incoming materials to your site? Please provide as a unit of measure or percentage of total incoming waste.

*This question was poorly answered therefore the results were discarded*

15. Does this combination of materials compost well together?

θ yes θ no

| Composts well together | Private (%) | Public (%) |
|---|---|---|
| Yes | 71 ± 3 | 100 ± |
| No | 14 ± 4 | - |

16. Does this operation reject any items? If yes, please list with explanation.

*Common responses were tallied and summarized as follows.*

| Reject Items | Private (%) | Public (%) |
|---|---|---|
| Grass & yard waste | - | 9 ± 1 |
| Processed or large wood | 14 ± 4 | 31 ± 2 |
| Meat & household organics | - | 22 ± 2 |
| Acidic plant matter | - | 9 ± 1 |

17. How long does organic matter typically take to compost at this facility?

18. How long does compost typically cure at this composting facility?

| Time | to compost (%) | | to cure (%) | |
|---|---|---|---|---|
| | Private | Public | Private | Public |
| Less than 1 month | 29 ± 7 | 13 ± 1 | 0 | 4 ± 0 |
| 2-3 months | 43 ± 7 | 4 ± 0 | 29 ± 7 | 13 ± 1 |
| 3-4 months | 14 ± 4 | 4 ± 0 | 29 ± 7 | 22 ± 2 |
| 4 or more months | 14 ± 4 | 65 ± 2 | 29 ± 7 | 39 ± 2 |
| Sold before cured | - | 4 ± 0 | 14 ± 4 | 4 ± 0 |

19. Please identify and rate the equipment used in the operation. Provide models and number of each type of equipment, check 1 maintenance box and provide any comments.

| Equipment Used | Private (%) | Public (%) |
|---|---|---|
| Front-end loader | 43 ± 9 | 65 ± 2 |
| Screen | 29 ± 7 | 35 ± 2 |
| Windrow turner | 43 ± 9 | 17 ± 1 |
| Tractor | 43 ± 9 | 17 ± 1 |
| Dump truck | 29 ± 7 | 9 ± 1 |
| Invessel system | 29 ± 7 | 17 ± 1 |
| Grinder | 14 ± 4 | 44 ± 3 |
| Rented | - | 35 ± 2 |

20. Is odour management an operational issue at this composting facility?

θ yes θ no

| Odour management an issue | Private (%) | Public (%) |
|---|---|---|
| Yes | 57 ± 9 | 26 ± 2 |
| No | 43 ± 9 | 74 ± 2 |

21. If odour complaints occur, how are they handled? Please explain your course of action.

*Common responses were tallied and summarized as follows.*

| Handling odour complaints | Private (%) | Public (%) |
|---|---|---|
| Stop operations | 29 ± 8 | - |
| Investigate the complaint | 14 ± 4 | 22 ± 2 |
| Talk with complainant | 14 ± 4 | - |
| Work according to conditions | 14 ± 4 | 31 ± 2 |
| No complaints | - | 13 ± 1 |

22. What are your comments on the quality of the final compost product you have produced?

| Compost product | Good (%) | | Acceptable (%) | | Has potential (%) | |
|---|---|---|---|---|---|---|
| | Private | Public | Private | Public | Private | Public |
| As a soil conditioner | 86 ± 4 | 74 ± 2 | 14 ± 4 | 13 ± 1 | 0 | - |
| As an amendment or fertilizer | 57 ± 9 | 57 ± 3 | 14 ± 4 | 13 ± 1 | 29 ± 7 | 9 ± 1 |
| As a blending material | 100 ± | 74 ± 2 | 0 | 13 ± 1 | 0 | 4 ± 0 |

23. Do you experience changes in the quality of your product(s)?

θ yes θ no

| Changes in quality of product | Private (%) | Public (%) |
|---|---|---|
| Yes | 43 ± 9 | 35 ± 2 |
| No | 57 ± 9 | 65 ± 2 |

24. Would you attribute these changes in compost quality to: (check any that apply)

θ quality of incoming materials
θ contamination of incoming materials
θ imbalance of nutrients within the incoming organics
θ moisture imbalances within the incoming organics
θ fungus or disease on the incoming organics
θ other _____

| Changes in compost quality | Private (%) | Public (%) |
|---|---|---|
| Quality of incoming materials | 29 ± 8 | 22 ± 2 |
| contamination of incoming materials | 14 ± 4 | - |
| imbalance of nutrients within the incoming organics | 14 ± 4 | 4 ± 0 |
| moisture imbalances within the incoming organics | 14 ± 4 | 17 ± 1 |
| fungus or disease on the incoming organics | - | 4 ± 0 |

25. How are these changes in compost quality dealt with?

θ reject a specific item
θ contact the source and work out a solution
θ change the composting process to accommodate this item
θ other _____

| Dealing with changes in compost quality | Private (%) | Public (%) |
|---|---|---|
| Reject item | 14 ± 4 | 4 ± 0 |
| Contact source | 14 ± 4 | 9 ± 1 |
| Change process | 29 ± 7 | 17 ± 1 |

26. Do you have an on-site topsoil blending process?

θ yes θ no
θ have an off site option

| On-site blending process | Private (%) | Public (%) |
|---|---|---|
| Yes | 57 ± 9 | 8 ± 1 |
| No | 43 ± 9 | 87 ± 1 |
| Off-site option | - | 4 ± 0 |

27. Do you have an on-site bagging process?

θ yes θ no
θ have an off site option

| On-site bagging process | Private (%) | Public (%) |
|---|---|---|
| Yes | 57 ± 9 | 1 ± 0 |
| No | 43 ± 9 | 96 ± 0 |

28. How does organic material arrive at this site?

θ contractor drop off
θ private drop off
θ other _____
θ municipal collection system
θ we do our own collection

| Material arrival on site | Private (%) | Public (%) |
|---|---|---|
| contractor drop off | 43 ± 9 | 57 ± 3 |
| municipal collection system | 28 ± 8 | 65 ± 2 |
| private drop off | 14 ± 4 | 9 ± 1 |
| we do our own collection | 14 ± 4 | 9 ± 1 |

29. Preferred method of collection by your operation (for small volumes)

θ plastic bags
θ bins/carts
θ other _____
θ paper bags
θ loose drop off

| Preferred method of collection | Private (%) | Public (%) |
|---|---|---|
| plastic bags | - | 26 ± 2 |
| paper bags | 43 ± 9 | 31 ± 2 |
| Bins / carts | - | 39 ± 2 |
| loose drop off | 43 ± 9 | 43 ± 3 |

30. How often are materials brought onto site?

θ daily
θ weekly
θ bi-weekly
θ drop off any time

| | Private (%) | Public (%) |
|---|---|---|
| Daily | 86 ± 4 | 65 ± 2 |
| bi-weekly | - | - |
| Weekly | - | 4 ± 0 |
| drop off any time | 14 ± 4 | 22 ± 2 |

31. Do you or have you experience(d) contamination issues with any of the following items? (check any that apply)

θ plastics
θ pesticides
θ medical wastes
θ other _____
θ oils
θ salts
θ metals

| Contamination issues | Private (%) | Public (%) |
|---|---|---|
| Plastics & household items | 71 ± 3 | 65 ± 2 |
| Oils / salts / metals | - | 4 ± 0 |

32. How many types of compost product does this facility produce?

| Number of compost products produced | Private (%) | Public (%) |
|---|---|---|
| One | 29 ± 7 | 61 ± 2 |
| Two | - | 26 ± 2 |
| Three | 43 ± 9 | 4 ± 0 |
| Four or more | 29 ± 7 | - |

33. Have you experienced difficulties selling your compost product?

θ yes θ no

| Difficulty selling compost | Private (%) | Public (%) |
|---|---|---|
| Yes | 29 ± 7 | 13 ± 1 |
| No | 71 ± 3 | 57 ± 3 |
| Give away to residents | - | 13 ± 1 |

34. Please provide the sale price of a unit of your finished compost product. Please list up to four of your most popular items.

*This question was not well answered, therefore the results were discarded.*

35. Do you feel the cost of producing this compost product is reasonable

| Cost of production | High (%) | | Acceptable (%) | | Low (%) | |
|---|---|---|---|---|---|---|
| | Private | Public | Private | Public | Private | Public |
| As a producer | 0 | - | 71 ± 3 | 30 ± 2 | 29 ± 7 | 39 ± 2 |
| As a consumer | 0 | 4 ± 0 | 43 ± 9 | 13 ± 1 | 29 ± 7 | 22 ± 2 |

36. Are there limitations to your ability to market your compost product?

θ yes θ no
θ comments _____

| Limitations for compost marketing | Private (%) | Public (%) |
|---|---|---|
| Yes | 43 ± 9 | 52 ± 3 |
| No | 57 ± 9 | 22 ± 2 |

37. Is there a demand for your compost product?

θ yes θ no

| Demand for compost product | Private (%) | Public (%) |
|---|---|---|
| Yes | 100 ± | 91 ± 9 |
| No | - | 4 ± 0 |

38. Do you have an established market / clients for your compost product?

θ yes θ no

| Established Market for compost | Private (%) | Public (%) |
|---|---|---|
| Yes | 86 ± 4 | 57 ± 3 |
| No | 14 ± 4 | 35 ± 2 |

39. Is there a greater demand for certain types of products?

θ pure finished compost
θ blended compost
θ finer screened compost
θ other _____

| Demand for compost products | Private (%) | Public (%) |
|---|---|---|
| Pure finished compost | 14 ± 4 | 31 ± 2 |
| Blended compost | 29 ± 7 | 9 ± 1 |
| Finer screened compost | 14 ± 4 | 26 ± 2 |
| Other | 29 ± 7 | 4 ± 0 |

40. Do customers generally prefer this product to be:

θ bagged θ loose or bulk

| Customer preference of compost | Private (%) | Public (%) |
|---|---|---|
| Bagged | 29 ± 7 | - |
| Bulk | 29 ± 7 | 44 ± 3 |
| No choice (only bulk available) | 29 ± 7 | 22 ± 2 |

41. Who do you sell your compost products to? (check any that apply)

θ landscapers
θ local contractors
θ used on site for dressing
θ other _____
θ nurseries
θ any member of the public

| Sell compost products to | Private (%) | Public (%) |
|---|---|---|
| Landscapers / contractors | 100 ± | 91 ± 1 |
| Nurseries | 29 ± 7 | 13 ± 1 |
| Used on site | - | 17 ± 1 |
| Topsoil blenders | - | 9 ± 1 |
| Public | 71 ± 3 | 31 ± 2 |

42. During the siting process to establish this operation what types of issues were experienced? (check any that apply)

θ community opposition
θ ministry approval
θ lack of capital - start up costs
θ other _____

| Siting issues experienced | Private (%) | Public (%) |
|---|---|---|
| community opposition | 14 ± 4 | 13 ± 1 |
| ministry approval | 86 ± 4 | 57 ± 3 |
| lack of capital / start up costs | 14 ± 4 | 22 ± 2 |

43. Please provide some idea as to what the primary concerns of the local community were during the siting process? (check any that apply)

θ odour θ aesthetics θ local employment
θ general lack of information sharing amongst shareholders
θ general lack of understanding of the composting process
θ other _____

| Community concerns during siting | Private (%) | Public (%) |
|---|---|---|
| Odour | 57 ± 9 | 30 ± 2 |
| Lack of understanding | 29 ± 7 | 13 ± 1 |
| Aesthetics | 43 ± 9 | 13 ± 1 |

44. Issues surrounding the composting process that affect your operation. (check any that apply)

θ financial status
θ site aesthetics
θ sales
θ offering a variety of products
θ other _____
θ community image
θ quality of the product
θ advertising
θ offering a value added product

| Issues that affect composting operation | Private (%) | Public (%) |
|---|---|---|
| financial status | 29 ± 7 | 39 ± 2 |
| site aesthetics | 14 ± 4 | 17 ± 1 |
| community image | 29 ± 7 | 22 ± 2 |
| quality of the product | 43 ± 9 | 35 ± 2 |
| Sales & advertising | 71 ± 3 | 21 ± 2 |
| offering a variety of products | 14 ± 4 | - |
| offering a value added product | 29 ± 7 | 9 ± 1 |

45. What are the reactions from neighbours of your site since operations have commenced?

θ generally acceptance/ support of the operation
θ no reaction
θ some opposition
θ strong opposition
θ other _____

| Neighborhood reactions | Private (%) | Public (%) |
|---|---|---|
| General acceptance / support | 57 ± 9 | 35 ± 2 |
| No reaction | - | 39 ± 2 |
| Some opposition | 43 ± 9 | 4 ± 0 |
| Strong opposition | - | 4 ± 0 |

46. Based on government regulations on composting and siting, during the siting process for this composting facility would you say that:

θ approval was easy to obtain
θ there was some difficulty obtaining approval
θ it was quite difficult to obtain approval
θ other _____

| Government issues during siting | Private (%) | Public (%) |
|---|---|---|
| approval was easy to obtain | 14 ± 4 | 48 ± 3 |
| there was some difficulty obtaining approval | 57 ± 9 | 44 ± 3 |
| it was quite difficult to obtain approval | 29 ± 7 | 4 ± 0 |

47. Based on community reactions, during the siting process for this composting facility would you say that:

θ approval was easy to obtain
θ there was some difficulty obtaining approval
θ it was quite difficult to obtain approval
θ other _____

| Community issues during siting | Private (%) | Public (%) |
|---|---|---|
| approval was easy to obtain | 57 ± 9 | 61 ± 2 |
| there was some difficulty obtaining approval | 29 ± 7 | 4 ± 0 |
| it was quite difficult to obtain approval | - | 9 ± 1 |

48. Is this composting facility located in a predominantly:

θ rural area θ urban area

| Location of composting operation | Private (%) | Public (%) |
|---|---|---|
| Rural area | 71 ± 3 | 48 ± 3 |
| Urban area | 29 ± 7 | 52 ± 3 |

49. How close are your closest neighbours (in km)?

| Distance from neighbours | Private (%) | Public (%) |
|---|---|---|
| Residential < 0.5km | 43 ± 9 | 30 ± 2 |
| Residential 0.5 – 1.0 km | 29 ± 7 | 44 ± 3 |
| Residential > 1.0 km | 14 ± 4 | 13 ± 1 |
| ICI < 0.5km | 14 ± 4 | 39 ± 2 |
| ICI 0.5 – 1.0 km | 14 ± 4 | 13 ± 1 |
| ICI > 1.0 km | 29 ± 7 | 13 ± 1 |

50. What are the local community reactions and/or thoughts on this composting operation?

θ agree that it is a good thing
θ oppose the idea (for any reason)
θ participate in concerns and decision making process
θ are interested in purchasing and using the product

| Community reactions / thoughts to composting operation | Private (%) | Public (%) |
|---|---|---|
| agree that it is a good thing | 43 ± | 78 ± 2 |
| oppose the idea | 14 ± 4 | 71 ± 2 |
| participate in concerns and decision making process | - | 13 ± 1 |
| are interested in purchasing and using the product | 14 ± 4 | 31 ± 2 |

51. Is this company involved in any community events etc.?

θ in cooperation with local parks (i.e. municipal government)
θ gardening / community groups
θ food bank
θ communities in bloom program
θ other _____

| Company involvement in community events | Private (%) | Public (%) |
|---|---|---|
| In cooperation with local parks | 57 ± 9 | 26 ± 1 |
| Gardening / community groups | 71 ± 3 | 30 ± 2 |
| Food bank | 14 ± 4 | 17 ± 1 |
| Communities in bloom program | 14 ± 4 | 9 ± 1 |

52. Do you think that waste management is a generally an important issue?

θ yes θ no

53. Do you think that waste should be managed locally?

θ yes θ no

54. Do you think that waste is being viewed as a resource by more people these days?

θ yes θ no

55. Do you agree with user pay systems for more effective waste management?

θ yes θ no
θ comments _____

56. Do you think that municipal composting programs should include kitchen wastes?

θ yes θ no
θ comments _____

57. Do you agree that backyard composting programs are an effective way to divert organic wastes from landfill?

θ yes θ no
θ any comments? _____

| Question | Yes (%) | | No (%) | |
|---|---|---|---|---|
| | Public | Private | Public | Private |
| Q 52 Do you think that waste management is generally an important issue | 100 ± 0 | 100 ± | - | - |
| Q 53 Do you think waste should be managed locally? | 100 ± 0 | 71 ± 3 | - | 29 ± 7 |
| Q 54 Do you think that waste is being viewed as a resource by more people these days? | 83 ± 2 | 57 ± 9 | 17 ± 1 | 43 ± 9 |
| Q 55 Do you agree with user pay systems for more effective waste management? | 83 ± 2 | 71 ± 3 | 13 ± 1 | 1 ± 0 |
| Q 56 Do you think municipal composting programs should include kitchen wastes? | 74 ± 2 | 71 ± 3 | 13 ± 1 | 1 ± 0 |
| Q 57 Do you agree that backyard composting programs are an effective way to divert organic wastes from landfill? | 83 ± 2 | 71 ± 3 | 17 ± 1 | 29 ± 7 |

58. What are the most challenging issues facing your facility? (check any that apply)

θ developing a good compost product
θ funding to keep operation going
θ competitive fees at landfill sites
θ maintaining supply to clients
θ adhering to compost quality standards
θ other _____
θ community relations
θ marketing your product
θ odour management
θ building revenues
θ maintenance of equipment

| Challenging Issues | Private (%) | Public (%) |
|---|---|---|
| Equipment maintenance | 57 ± 9 | 35 ± 2 |
| Quality standards | 29 ± 7 | 9 ± 1 |
| Competitive tip fees | 29 ± 7 | 13 ± 1 |
| Marketing and maintaining supply | 57 ± 9 | 30 ± 2 |
| Funding and building revenues | 57 ± 9 | 35 ± 2 |
| Community relations / odour | 43 ± 9 | 22 ± 2 |
| Developing a good product | 86 ± 4 | 44 ± 3 |

59. What is the most important "R"? (choose only one)

θ refuse
θ reuse
θ reduce
θ recycle

| Most important "R" | All (%) |
|---|---|
| Refuse | - |
| Reduce | 69 ± 2 |
| Reuse | 6 ± 0 |
| Recycle | 16 ± 1 |

60. Overall thoughts on composting - any comments at all.

_____
_____
_____

## Appendix B

User survey

# Survey for Compost Users in Ontario

***Confidence intervals are significant to 95% based on the normal approximation to the binomial distribution.*

1. How much compost and/or compost blended material do you annually use or purchase? Please choose one unit of measurement for both compost and blended compost.

| Volume of Compost Used | Compost | Blended Compost |
|---|---|---|
| Average $m^3$ | 1001 | 3501 |
| Total ($m^3$) | 19573 | 17092 |

Responses were received in $m^3$, $yd^3$ and metric tonnes. Cubic yards were converted to cubic meters by a factor of 1.3 (1 $yd^3$ = 1.3 $m^3$ or 1 $m^3$ = 0.76 $yd^3$). The difference between cubic meters and cubic yards is negligible considering that most operations were providing estimates. Since the wet or dry bulk densities were not reported in the responses a density of 541.5 $kgm^{-1}$ was used to calculate all responses into cubic meters. (U. Stoklas pers com., 1999). Of the 42 compost users that responded to the survey, 37 (88%) provided data to this question.

2. Is delivery of the compost included in the price?

   θ yes
   θ no

| Delivery included in price | Response (%) |
|---|---|
| Yes | 57 ± 1 |
| No | 19 ± 1 |

3. How much do you *actually pay* for compost product? Please choose one unit of measurement for both bagged and bulk/loose compost.

| Average paid for compost ($) | Bagged | | Bulk | |
|---|---|---|---|---|
| | compost | Blended compost | Compost | blended compost |
| Average ($m^3$) | 74 | 113 | 19 | 21 |

* 39 values were used to calculate these final values. Where a range was given by the respondent an average was calculated for their response and used as one response for that respondent

4. In which form do you prefer to purchase compost?

- θ bagged
- θ bulk or loose (i.e. by the truck load)

| Prefer to purchase compost | Response (%) |
|---|---|
| Bagged | 17 ± 1 |
| Bulk/ loose | 67 ± 1 |

5. How much would you be *willing to pay* for good quality compost and blended compost? Please choose one unit of measurement for both compost and blended compost.

| Average paid for compost ($) | Bagged | | Bulk | |
|---|---|---|---|---|
| | compost | Blended compost | Compost | blended compost |
| Average ($m^3$) | 11 | 21.59 | 15.66 | 22.69 |
| *36 values were used to calculate these final values. Where the respondent gave a range an average was calculated for their response and used as one response for that respondent. | | | | |

6. Do you prefer to purchase:

- θ pure compost
- θ blended compost

| Prefer to purchase | Response (%) |
|---|---|
| Pure compost | 36 ± 1 |
| Blended compost | 48 ± 1 |

7. If you prefer blended compost product what is the desired mix ratio [compost:blending material] you prefer to use? Please provide 1 or 2 preferences and the blending material (i.e. soil etc.)

*This question was not well answered therefore, the results were discarded.*

8. If you prefer to purchase pure compost, do you do your own custom blending?

- θ yes
- θ no

| Do own blending | Response (%) |
|---|---|
| Yes | 45 ± 1 |
| No | 24 ± 1 |

9. How would you say that the price of compost fluctuates?

- θ seasonally (i.e. spring, summer, fall, winter)
- θ does not fluctuate
- θ other _____

| Price of compost fluctuates | Response (%) |
|---|---|
| Seasonally | 5 ± 1 |
| Does not fluctuate | 57 ± 1 |

10. How is the compost you purchase used?

- θ used on site (i.e. dressing, landscaping)
- θ used off-site (i.e. at contracting locations)
- θ sold from your site as a retail product

| Use of purchased compost | Respondents (%) |
|---|---|
| Used on site | 64 ± 1 |
| Used off site | 26 ± 1 |
| Sold as a retail product | 26 ± 1 |
| Two or more responses | 31 ± 1 |

11. What type of applications do you use compost for?

- θ nursery potting mix
- θ landscaping/contracting
- θ topsoil fill amendment
- θ other (describe briefly) _____

| Compost used for | Respondents (%) |
|---|---|
| Nursery potting mix | 64 ± 1 |
| Landscaping/contracting | 36 ± 1 |
| Topsoil fill amendment | 26 ± 1 |
| Other | 14 ± 1 |

12. Over the past 5 years would you say that your use and/or sales of compost has generally:

- θ increased significantly
- θ increased slightly
- θ not really changed
- θ decreased slightly
- θ decreased significantly

| Use and/or sales of compost | Response (%) |
|---|---|
| Increased significantly | 33 ± 1 |
| Increased slightly | 38 ± 1 |
| not really changed | 21 ± 1 |
| Decreased slightly | - |
| Decreased significantly | - |

13. If your use and/or sales of compost have *increased*, what would you attribute this increase to? (check any that apply)

- θ increased quality compost on the market
- θ increased knowledge of the benefits of using compost
- θ problems with readily available peat
- θ consumer demand for natural products vs. synthetic fertilizers
- θ a recognition that the use of compost contributes to diversion of organics from landfills
- θ availability of compost has increased
- θ Other _____

| Use and/or sales of compost | Response (%) |
|---|---|
| Increased quality compost on the market | 17 ± 1 |
| Increased knowledge of the benefits of using compost | 43 ± 1 |
| Problems with readily available peat | 5 ± 1 |
| Consumer demand for natural products vs. synthetic fertilizers | 14 ± 1 |
| a recognition that the use of compost contributes to diversion of organics from landfills | - |
| Availability of compost has increased | 7 ± 1 |

14. Have you experienced any problems with the compost you have purchased?

| Problems with compost | Response (%) |
|---|---|
| Yes | 33 ± 1 |
| No | 12 ± 1 |

15. Would you say you are generally satisfied with the quality of the compost you are purchasing?

θ yes
θ no

| Satisfied with compost | Response (%) |
|---|---|
| Yes | 79 ± 1 |
| No | 12 ± 1 |

16. If you answered "*no*" to Q 15, how could the quality of the compost be improved? (check any that apply)

θ better blending
θ weed seed free
θ more curing
θ improved texture
θ lower salt content
θ other _____
θ disease free
θ less contamination
θ less coarse
θ lower pH
θ increased nutrient control

| How to improve compost quality | Response (%) |
|---|---|
| More curing | 5 ± 1 |
| Increased nutrient content | 5 ± 1 |
| Less contamination | 5 ± 1 |
| Weed seed / disease free | 12 ± 1 |
| Better blending / improved texture / less coarse | 12 ± 1 |

17. If you have experienced difficulty with the compost you have purchased, were you able to successfully approach the producer regarding this issue?

θ yes
θ no

| Problems with compost and approaching producer | Response (%) |
|---|---|
| Yes | 33 ± 1 |
| No | 12 ± 1 |

18. Further to Q 17, what was the response of the compost producer?

- θ offer to examine product
- θ offer to examine product and replace it
- θ offer no help or suggestion to the issue
- θ ask how the product could be improved
- θ ask how the product could be improved and replace it
- θ treat the problem on site (if possible)
- θ I have never had problems with the product/producer
- θ other _____

| Suppliers response to user regarding problems with compost | Response (%) |
|---|---|
| Offer to examine the product | 10 ± 1 |
| Offer to examine the product and replace it | 5 ± 1 |
| Offer no help or suggestion | 2 ± 1 |
| Ask how compost can be improved | 17 ± 1 |
| Never had a problem with compost | 7 ± 1 |

19. If you sell compost as a retail product, what is most requested by your customers/clients?

- θ bagged pure compost
- θ bagged blended compost
- θ bulk/loose pure compost
- θ bulk/loose blended compost
- θ other (i.e. not applicable, no requests) _____

| Product most requested | Response (%) |
|---|---|
| Bagged pure compost | 17 ± 1 |
| Bagged blended compost | 21 ± 1 |
| Bulk/loose pure compost | 7 ± 1 |
| Bulk/loose blended compost | 14 ± 1 |

20. What most accurately describes the nature of your business?

- θ nursery
- θ garden centre
- θ landscaper/contractor
- θ other _____

| Nature of Business | Response (%) |
|---|---|
| Nursery | 52 ± 1 |
| Garden centre | 60 ± 1 |
| Landscaper / contractor | 36 ± 1 |
| Other (blender) | 10 ± 1 |

21. Is the compost you purchase produced locally (within 30 km of your operation)?

- θ yes
- θ no (further than 30km)

| Compost produced locally | Response (%) |
|---|---|
| Yes (within 30km) | 45 ± 1 |
| No | 43 ± 1 |

22. Would you say there is a sense of competition amongst compost producers to provide a good quality product at a reasonable price?

- θ yes
- θ no

| Competition amongst compost producers | Response (%) |
|---|---|
| Yes | 48 ± 1 |
| No | 36 ± 1 |

23. Do you feel there are an adequate amount of educational resources available on compost (i.e. the use and benefits of composting)?

- θ yes
- θ no

| Competition amongst compost producers | Response (%) |
|---|---|
| Yes | 48 ± 1 |
| No | 38 ± 1 |