ASSESSMENT OF THE PRACTICE AND POTENTIAL OF INDUSTRIAL SOLID WASTE MINIMISATION: CASE STUDY OF STELLENBOSCH

Belemane Petrose Semoli

Thesis presented in partial fulfilment of the requirements for the degree of Master of Science at the University of Stellenbosch.

SUPERVISOR: Dr P.H. De Necker

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Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

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ABSTRACT

There is increasing pressure on factories and government to practise cleaner technology. The public is becoming more and more environmentally aware and external pressure from international competitors is also forcing companies to adopt environmentally sound production practices. Our natural resources and the environment need environmentally friendly practices. Waste minimisation is not only prudent practice for manufacturing industries, but is also an integral part of environmental regulations in many countries, including South Africa. This research seeks to investigate the extent and potential for industrial waste minimisation in Stellenbosch.

The objectives of this thesis are, firstly to establish and evaluate the present range and extent of industrial solid waste minimisation practices; secondly to identify and evaluate potential industrial solid waste minimisation measures that could (if necessary) be instituted in future; and finally to propose a general strategy for the minimisation of industrial solid waste in Stellenbosch.

The findings reflect that currently there is little waste minimisation awareness and practice in Stellenbosch. The most common method of waste minimisation currently practised by industries is recycling through the selling of recyclables. The least common method is the equipment-related change method, due to the high costs involved in adopting this method. Based on the findings, a suitable regional waste management strategy was developed and this strategy could possibly be adopted elsewhere in South Africa.

Key words: waste minimisation, waste management, re-use, recycling, factory, environment, practice, participation, cleaner technology, awareness, Stellenbosch

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OPSOMMING

Daar is toenemende druk op fabrieke sowel as op die regering om skoner tegnologie te beoefen. Die publiek raak ook toenemend meer omgewingsbewus en druk vanaf die kant van internasionale mededingers forseer maatskappye om praktyke in te stel wat gunstig is ten optigte van die omgewing. Ons natuurlike hulpbronne en die omgewing benodig omgewingsvriendelike vervaardigingspraktyke. Die beperking van afvalstowwe is nie net vir die fabriekswese 'n wyse praktyk nie, maar maak ook in vele lande, met inbegrip van Suid-Afrika, 'n integrale deel uit van regulasies met betrekking tot die omgewing.

Hierdie navorsingsprojek poog om die omvang en potensiaal van beperking van afvalstowwe in Stellenbosch te ondersoek. Die doelwitte van die ondersoek is eertens om ondersoek in te stel na die huidige reikwydte en omvang van praktyke om vaste industriële afvalstowwe te beperk en dit te evalueer; tweedens om potensiële industriële vaste afvalstofbeperkingsmaatreëls wat, indien nodig, in die toekoms ingestel sou kon word, te indentifiseer en te evalueer; en dan uiteindelik 'n algemene strategie vir die beperking van vaste industriële afvalstowwe in Stellenbosch voor te stel.

Die bevindings in hierdie tesis bewys dat daar tans geringe bewustheid van die noodaaklikheid van afvalstofbeperking in Stellenbosch is en dat dit ewe min in die praktyk toegepas word. Die mees algemene vorm van beperking van afvalstowwe in die fabriekswese is deur middel van verkoop van herwinbare afvalstowwe. Die mins algemene vorm van beperking van afvalstowwe hou verband met die vervanging van toerusting. Die rede hiervoor het te doen met die koste verbonde aan die strategie.

Vanuit hierdie bevindings is toepaslike strategie vir die bestuur van afvalstowwe op streeksvlak ontwikkel. Hierdie strategie sou moontlik ook elders in Suid-Afrika toegepas kon word.

Sleutelwoorde: beperking van afvalstowwe, afvalstofbestuur, hergebruik, herwinning, fabriek, omgewing, praktyk, deelname, skoner tegnologie, bewustheid, Stellenbosch

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May God bless you!

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ACRONYMS

IWM	Integrated waste management
WM	Waste minimisation
ERC	Equipment-related change
PRC	Personnel-related change
MRC	Material-related change
MS	Material(s) sold
MUFLQP	Material(s) used by firm for lower quality purpose
DWAF	Department of Water Affairs and Forestry
DEAT	Department of Environmental Affairs and Tourism
NEC	Not elsewhere classified
ISO	International Organisation for Standardization

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1. INDUSTRIAL WASTE AS AN ENVIRONMENTAL CONCERN

This study focuses on the minimisation of industrial solid waste in Stellenbosch. Before discussing the facts and problems of minimising industrial solid waste in Stellenbosch, the broader context of the study will be presented. The first subsection considers general issues surrounding the question of waste, particularly solid industrial waste and its role in creating or contributing to environmental problems. Issues of waste management, as well as the terminology regarding industrial waste and industrial waste minimisation, are also dealt with. The second subsection looks at the contribution of general waste minimisation to improved industrial waste minimisation, after which the problem of industrial waste in Stellenbosch is briefly set out. The final subsections are, research aims; data collection and the characteristics of the study area; and the research plan and research framework.

1.1 Waste management and the environment

Coleman (1994) reports that poor environmental management of industrial activities internationally has had global consequences in terms of both the depletion of natural resources and widespread pollution. Well-documented pollution effects include global destruction of the ozone layer, acid rain and the contamination of water and land by hazardous wastes. With regard to resource depletion, most industrial activity, and therefore also much resource depletion, has taken place in developed countries. However, pollution effects have also been associated with large-scale consumption of resources obtained from the less developed and poorer countries. This has resulted in the depletion of the local resource base in some areas, including degradation of soils, water, atmosphere and forests and loss of the agriculturally based economy in many places.

Fortunately many developed countries realise today that "end-of-pipe" treatment (i.e. disposing of or treating generated waste) is not the most efficient and cost-effective waste management method. What is needed are more comprehensive strategies which will bring about "sustainable development", i.e. development which can be indefinitely sustained because resource use as well as the emission of wastes (liquid, gaseous and solids) are kept to the lowest levels possible, but without limiting economic growth.

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For the purpose of better understanding of the terminology used in this thesis, it is necessary to define the terms used in the following paragraphs.

Factory or industrial undertaking: South Africa's census of manufacturing (1979) defines a factory as "the site of an institution in which manufacturing, processing, packaging, installation, assembly and repair of goods and articles take place" (South Africa, 1983). The Factory Act No. 137 of 1993 defines a factory as "a premises where an employer employs one or more employees and where an article or part of an article is made, manufactured, built, assembled, compiled, printed, processed, treated, repaired, renovated rebuilt, altered, ornamented, painted, polished, finished, cleaned, dyed, washed, broken up, disassembled, sorted, packed or put into a container, chilled frozen or stored in cold storage" (South Africa, 1993). This act repeals the Factory Act No. 104 of 1992.

There are other definitions of a factory but some of them are too narrow and vague for the purpose or scope of this study. The definition given by the census of manufacturing was used to identify the factories in Stellenbosch as it is wide and gives one a range of factories from which to select and the possibility of comparing different types of factories. The second definition is too wide and includes some small businesses as industries, making it unsuitable to this study. The 1979 definition of a factory or industrial undertaking was applied to a list of businesses in Stellenbosch to identify or determine the universe for the study. The list was obtained from the Stellenbosch municipality and this list was compiled in 1998.

Waste: In Section 1 of the Environmental Conservation Act, 1989 (Act No. 73 of 1989), waste is defined as an undesirable or superfluous by-product, emission, residue or remainder of any process or activity, any matter, gaseous, liquid or solid or any combination thereof, originating from any residential, commercial or industrial area (Shand, 1993).

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Solid waste is waste which is not liquid or gaseous, which is generated in residences, commercial facilities, institutions and industries or factories, and is generally classified as non-hazardous or hazardous waste.

Industrial solid waste: According to Porteous (1991: 358), "industrial waste is defined in the Control of Pollution Act of 1974 Section 30(3)(b) as consisting of waste from any factory within the meaning of the Factories Act 1961 and any premises occupied by a body corporate established by or under any enactment for the purpose of carrying on under national ownership any industry or part of an industry or any undertaking, excluding waste from any mine or quarry. Industrial solid waste is therefore generally taken to include waste from any industrial undertaking or organisation."

Allaby (1990), by contrast, defines industrial waste as any solid material that is discarded from trading, commercial and industrial premises, and requires disposal. Clearly this definition is too wide for the purpose of this research because it includes trading and commercial premises. For the purpose of this thesis solid waste originating in trading and commercial undertakings will be excluded, so that one is left with waste produced by factories or industrial undertakings as defined. Allaby (1990) divides industrial waste into five categories, namely (a) general factory rubbish uncontaminated by factory process waste; (b) relatively inert process waste; (c) flammable process waste; (d) acid or caustic waste; and (e) indisputably toxic waste.

Integrated waste management (IWM): Various definitions emphasize different aspects of the concept of integrated waste management. Thus Steyl (1996: 3) describes it as "purposeful, systematic control of the functional elements of generation, onsite storage, collection, transfer and transport, processing and recovery, and disposal associated with the management of solid waste from the point of generation to final disposal." This definition is represented diagrammatically in Figure 1. The Department of Environmental Affairs and Tourism (South Africa, 1998b), on the other hand, emphasises the purpose rather than the constituent aspects of integrated waste management. It describes IWM as a holistic and integrated system and process of management aimed at pollution prevention and minimisation at source. It continues by saying that it is the management

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of the impact of pollution and waste on the receiving environment and remediation of damaged environments.

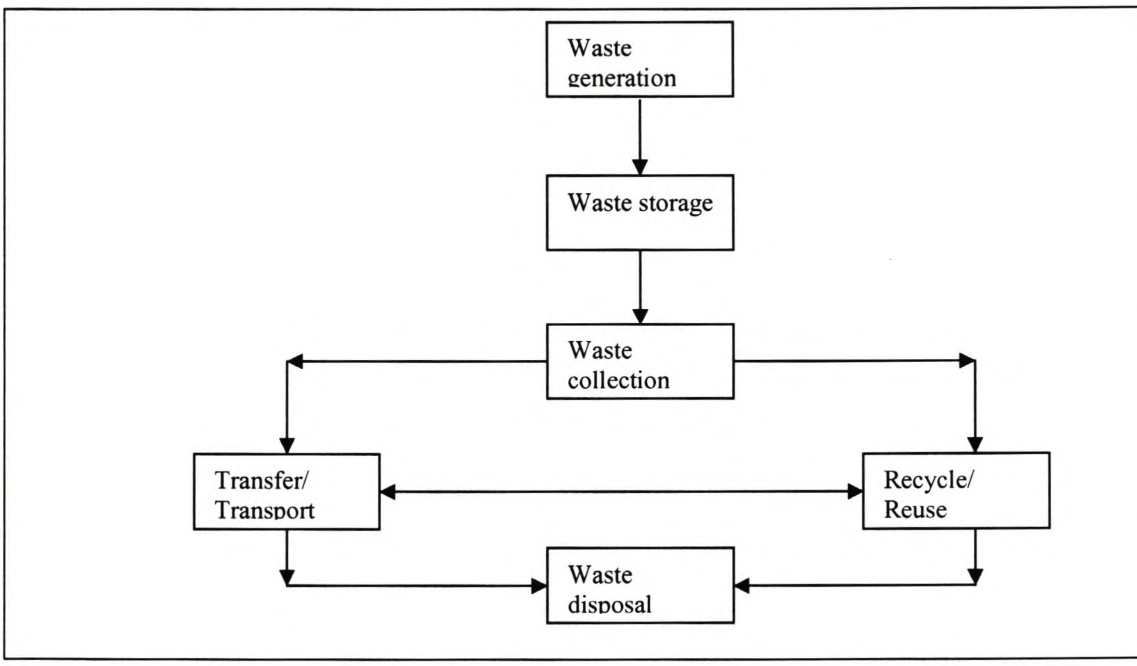

Figure 1. Elements in the waste management process
Source: Steyl (1996: 19)

On the other hand, the Fairest Cape Association (1998) has a different perspective, namely waste management as the use of a combination of alternative integrated waste management techniques to manage the waste management hierarchy and integrated solid waste management can include: source reduction/waste prevention, waste minimisation, recycling or disposal through, for example, composting, combustion or land disposal. This definition is illustrated in Figure 2.

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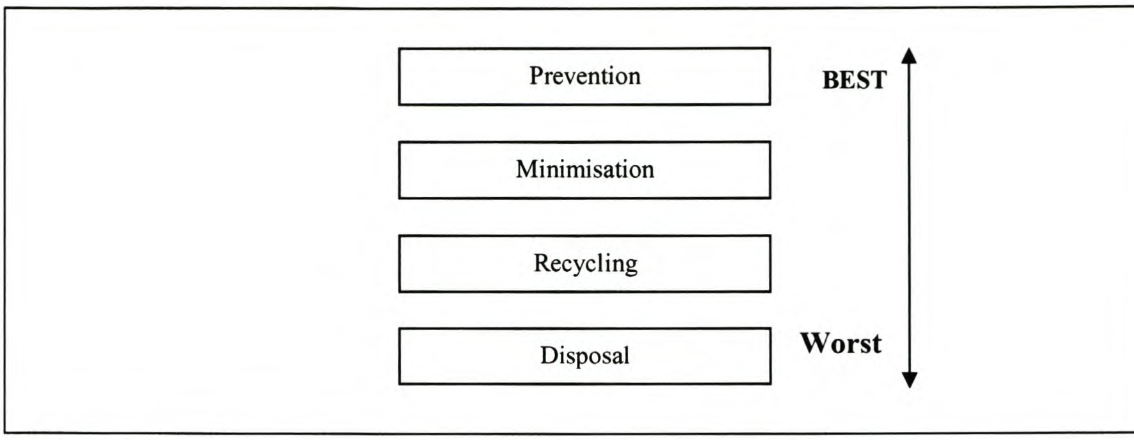

Figure 2. Hierarchy of waste management options
Source: Crittenden & Kolaczkowski (1995: 5)

Clearly, waste minimisation is very important in the waste management hierarchy, being the preferred option if the generation of waste cannot be prevented.

Waste minimisation (WM): According to Harries (1993: 41) "waste minimisation is not only a prudent step for industries to take but it is also an integral part of environmental regulations". Clark (1995: 17), describes WM as "a technique, process or activity that either avoids, eliminates or reduces waste at its source". (South Africa, 1994) is less specific and describes WM as "any action that is taken to reduce the volume and toxicity of waste, specifying avoidance of waste generation, recycling, recovery and utilisation as the options in this regard".

As the waste management concepts are discussed above, the next section outlines the waste minimisation as part of waste management. The pyramid in Figure 3 shows the preferred preventative options of WM in a WM hierarchy, more detail on the principles and methods of WM is presented in Section 1.2.

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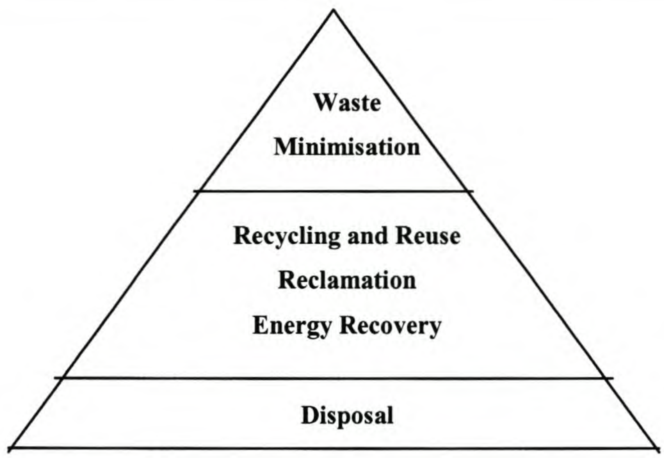

Figure 3. Hierarchy of waste management options and preventative options

Source: Fairest Cape Association (1998)

1.2 Waste minimisation as a contribution to improved waste management

Waste materials will always be generated during manufacturing of products. Besides creation of environmental problems, there is also a need for manufacturers to embark on environmentally sound pollution control measures (Crittenden & Kolaczkowski, 1995). Pollution is both an environmental and human health concern globally. The magnitude and extent of pollution impacts are not really known hence it is deemed that the best approach to manage the impacts is by avoiding or producing pollution at minimum levels (Rossiter & Kumana, 1995: 44). Integrated waste management, with its objective of reducing the quantity and toxicity of waste for final disposal and obtaining sustainability, is now an accepted approach in international waste management. The 1992 Earth Summit in Rio de Janeiro set a series of Agenda 21 objectives for sustainable environmental management. The main theme of this was to assess the nature of sustainable developments by the adoption of environmentally sound waste management technologies including waste minimisation (Fairest Cape Association, 1998).

Waste minimisation thus forms one component of any integrated waste plan but WM alone cannot solve all solid waste problems. WM should be properly incorporated in the IWM plan, which considers all components of the waste plan in such a way that they

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complement each other. Other components which, according to the Fairest Cape Association (1998), need to be included are:

- Internal recycle and reuse
- External waste recycling and reuse
- Composting of organic waste
- Waste treatment
- Incineration of waste
- Controlled disposal
- Uncontrolled disposal.

Agenda 21 provides a global context for WM strategies, namely "Environmentally sound waste management must go beyond the mere safe disposal, or recovery, of waste that is generated and seek to address the root cause of the problem by attempting to change unsustainable patterns of production and consumption" (Ball, 1999: 19). A waste minimisation strategy is therefore the most important component of a company's environmental management system.

1.3 The problem of industrial waste in Stellenbosch

Historically, waste management has not been regarded as a priority issue in South Africa. The waste management that has taken place focussed mainly on waste disposal alone, and was reactive in that it generally only sought to address pressing waste collection and disposal needs. Industrial waste, like other wastes generated in South Africa, is commonly managed by "end-of-pipe" technologies and there are serious environmental consequences associated with this approach. Holistic integrated waste management planning is rarely, if ever, undertaken. The low priority accorded waste management has resulted in waste impacting detrimentally on the South African environment and on human health (Environmental Monitoring Group, 1993). This is the case in Stellenbosch as well - hence the initiation of this study to investigate the current situation regarding industrial waste and develop an integrated waste management strategy for Stellenbosch.

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It is against this background that the present study attempts to establish the contribution which is being, and can potentially be, made by measures aimed at minimising the volume of industrial solid waste. This will be done by means of a case study of Stellenbosch.

1.4 Study area

In choosing Stellenbosch as a study area, four factors were taken into account. There is a variety of factory types; the number of factories is manageable for a Master's degree study; the manufacturing industries of Stellenbosch (like those elsewhere) manage waste produced during production by 'end-of-pipe' technologies; and this area is accessible and familiar to the researcher. The study area is the Stellenbosch industrial area (see Figure 4), where most of the town's factories are situated. However, there are also some which are not in the demarcated areas shown in Figure 4. Using a list obtained from the Municipality of Stellenbosch, which has all the physical addresses for the businesses in Stellenbosch, these industries, were located on a street map.

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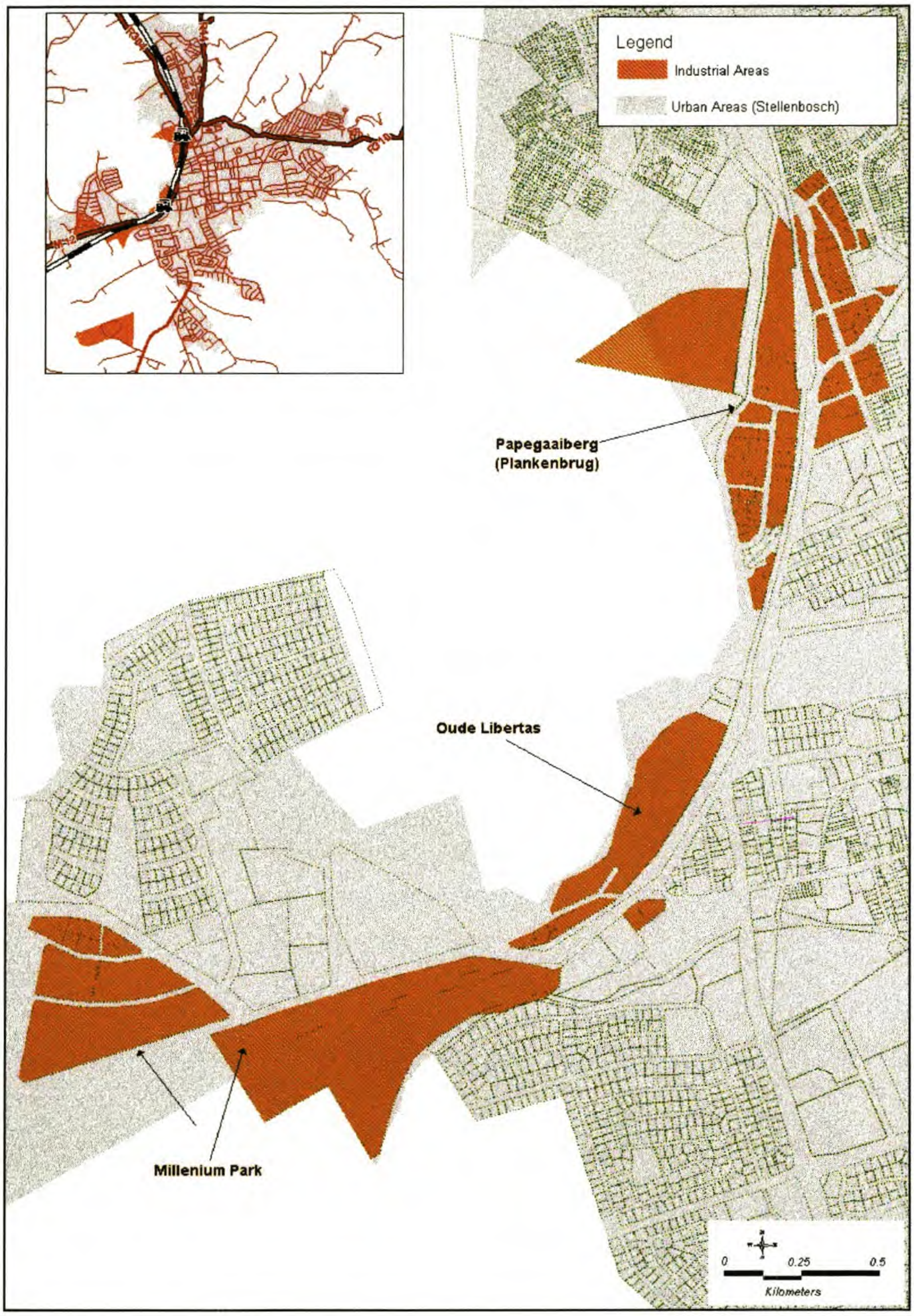

Figure 4: Study area - Stellenbosch industrial areas

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1.5 Objectives of the study

The principal objective of the study is to assess the practice and potential of industrial waste minimisation in Stellenbosch. More specifically, the study will attempt to:

- Establish and evaluate the range and extent of industrial solid waste minimisation practices in Stellenbosch in 1999;
- Identify and evaluate potential industrial solid waste minimisation measures that could (if necessary) be instituted; and
- Propose a general strategy for the minimisation of industrial solid waste in Stellenbosch.

1.6 Data identification and collection

These activities involved the three major steps set out below.

Literature search: An extensive literature search pertaining to industrial waste management in other parts of the world and in South Africa was conducted (Semoli, 1999). The aim was to identify existing practices in industrial waste management and, in particular, those pertaining to solid waste minimisation in the manufacturing industry. The literature comprised books, journal articles, local publications, newspapers and government publications.

Determination of the universe: The universe for the study was determined by making use of a list of all "businesses" (retail, wholesale, and industrial concerns) drawn up by the Stellenbosch Municipality in August 1998. The definition of a factory as "an institution on the site of which manufacturing, processing, packaging, installation, assembly and repair of goods and articles take place" was applied to each entry in the list and those that qualified were included in the universe (South Africa, 1983). Mr DJ Folscher (former chairman of the Stellenbosch Chamber of Commerce) helped to identify a total of 91 factories located in Stellenbosch's industrial areas. The list also provided the physical address of each factory.

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Questionnaire survey: Using a 50 per cent sample size and a stratified random sampling procedure, 48 questionnaires were distributed to selected factory managers in the Stellenbosch industrial areas. This sample size was selected to obtain a sufficient number of questionnaires and to make sure that all the different types of industries were represented in the sample population. The stratification was done by grouping factories by type and random sampling was done in selecting any factory within a group, with each factory having an equal chance of being selected. Whenever possible, the questionnaire was completed in the researcher's presence and, if not possible, it was left with the manager, to be collected later. The questionnaire is attached as Addendum.

For the purpose of sampling, factories were classified according to the South African Standard Industrial Classification (SIC) and a 50 per cent sample was randomly taken in each major group. The categories and the number of factories in each, together with the 50 per cent sample size, number of respondents and response rate are summarised in Table 1.

Table 1: Total number of factories in each category, sample size and number of Respondents, Stellenbosch 1999

SIC major group	Factory description	Number of factories	50% sample size	Number of Respondents	Response rate (%)
302	Manufacturing of dairy products	1	1	1	100
304	Manufacturing of other food products	4	2	2	100
305	Manufacturing of beverages	6	2	2	100
311	Spinning, weaving and finishing of textiles	5	3	1	33.3
317	Manufacturing of footwear	1	1	1	100
322	Manufacturing of products of wood, cork, straw and plaiting materials	12	6	6	100
325	Manufacturing of basic chemicals	1	1	1	100
342	Manufacturing of non-metallic mineral products NEC	4	2	2	100
355	Manufacturing of other fabricated metal products; metal work service activities	21	11	11	100
626	Maintenance and repair of motor vehicles	36	18	14	77.7
Total		91	48	41	87.5

Source: Industrial survey, 1999

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The questionnaire consisted of three sections relating to general information about the firm, the extent of waste generation, and the practice and potential of waste minimisation, respectively. A copy of the questionnaire is included as Addendum.

Out of the 48 questionnaires which were distributed, 41 were completed. This is a high response rate (85%) and the respondent firms represent all the factory types (SIC major groups) in the industrial areas in Stellenbosch. The questionnaires were collected and the answers were coded and analysed using MicroSoft Excel.

Personal interviews and observation: Non-structured interviews were conducted with major role players in the field of industrial waste management. The interviews were meant to get perceptions from the role players and experts on industrial waste minimisation. In certain instances the experts assisted by providing literature and sometimes with reference to other relevant role players. This was done after the collection of questionnaires from the sampled firms' managers in Stellenbosch. Non-structured interviews were conducted with role players from the CSIR, Stellenbosch Town Council, Winelands District Council, Stellenbosch Concerned Citizens' Group, Cape Metropolitan Council, Environmental Monitoring Group, Department of Water Affairs and Forestry, and Department of Environmental Affairs and Tourism.

Personal observation was carried out by visiting sites where waste is generated, treated and disposed of. Interesting activities were noted during the site visits and in some instances photographs taken.

1.7 Research plan and framework

The research design is represented in schematic form in Figure 5. Chapter 1 gives a general background to industrial waste and environmental concerns based on the findings from the literature search. It attempts to define some important concepts used in the thesis. It also gives the background on how waste management is related to integrated waste management. This is followed by a discussion of how industrial solid waste can cause a problem in Stellenbosch and elsewhere, based on findings reported in the literature. Finally the study area is described and the data collection methods set out.

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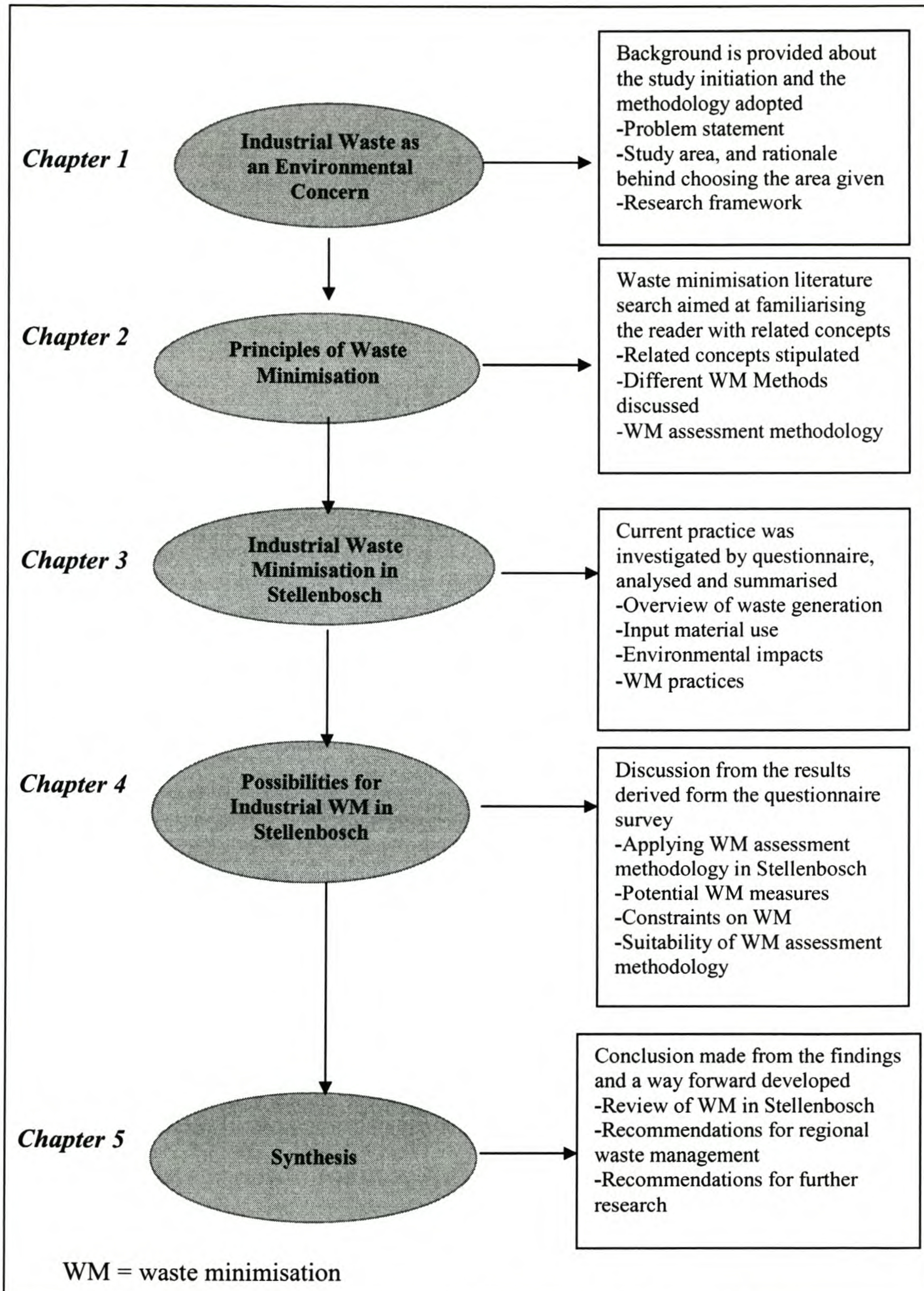

Figure 5: Research framework (Devised from ideas by De Necker, 1987)

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Chapter 2 gives the background for the principles of industrial waste minimisation. Concepts which are related to waste minimisation and different methods and techniques of waste minimisation are discussed. Waste minimisation assessment methodology is explained. Chapter 3 assesses the industrial waste management practices currently used in Stellenbosch as the environmental impacts associated with this also concern the input materials used and the waste generated by the factories. Chapter 4 reviews the possibilities for industrial waste minimisation in Stellenbosch and discusses the application of the waste management assessment methodology, the potential of waste minimisation measures, as well as the factories' responses. The constraints on waste minimisation and the suitability of waste minimisation assessment methodology are also elaborated. The final chapter, which is the synthesis, enumerates the review of waste minimisation in Stellenbosch. Recommendations for regional waste management are made, as well as recommendations for further research.

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2. PRINCIPLES OF WASTE MINIMISATION

In the previous chapter, the terminology used in this thesis was discussed and an attempt made to describe the link between waste minimisation and waste management. This chapter is aimed at describing waste minimisation and related concepts, methods of waste minimisation and waste minimisation assessment methodology.

2.1 Waste minimisation and related concepts

Trends in environmental management within developed countries have evolved primarily from a concern about the problems of waste generation and pollution. Consequently the more established environmental policies are based on principles of more responsible and appropriate waste management techniques. It is only more recently that concerns about the depletion of raw materials resources have also come to the fore.

Integrated waste management is based on a hierarchical approach to waste management which puts the primary emphasis on waste minimisation and this approach is being phased into production practices globally as a means to minimise pollution, improve occupational conditions and improve the public perception of industries' activities (Environmental Monitoring Group, 1993). Waste minimisation techniques such as source reduction and recycling cannot eliminate waste generation completely. No matter what systems are put in place to minimise waste there will always be limits to the efficiency of all processes of conversion, production, consumption and recycling, as well as possible technical or economic constraints, the possibility of achieving zero emissions is in most cases impossible or impractical. There will always be some residual waste for which appropriate "end-of-pipe" treatment processes and disposal practices need to be applied in such a way that environmental hazards be minimised (Taylor, 1993).

However, the first and most important component of waste management is prevention, its combination of resource conservation and waste avoidance making it cost-effective. The realistic methods of prevention for manufacturing industries are waste prevention by improved materials handling and storage, together with the use of clean technologies, with increased yield, less by-products and side streams (Jackson, 1991).

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Clean production does not imply only the adoption of industrial processes aimed at reducing the consumption of natural resources, including raw materials, water and energy, and elimination of the generation of waste materials, but also includes practices which ensure that products are environmentally compatible throughout their life cycles. Clean production also includes economic and social changes in business practices, consumption patterns and consumer behaviour (Jackson, 1991). *Clean technology* is regarded as a subset of clean production, i.e. technology which improves the mechanical efficiency of production processes and which substitutes less hazardous processes, products and activities for more harmful ones, thereby reducing quantities and/or the hazardous nature of waste materials which require treatment and disposal (Environmental Monitoring Group, 1993). Its implementation generally requires the re-evaluation of the traditional practices and process synthesis routes by new research and development. Clean technology is defined as "any environmental measure that is taken to contribute to the closure of the production-product life cycle. This could include the better use of raw materials, new processes, process integrated recycling, new product specifications and recycling of waste products as raw materials" (Sutter, 1989: 36)

2.2 Waste minimisation methods

A summary of practical minimisation techniques/methods which can be applied to waste generation problems is shown in Figure 6. The techniques fall into two broad categories – reduction of waste at source, and recycling. In principle, the former is preferable to the latter because the use of recycling infers that process plants, raw material flows and utility consumption will be higher and recycling will not be necessary. In practice, however, there are many factors involved which mean that most waste minimisation strategies involve some form of recycling, often in combination with reduction of waste at source and with changes to waste treatment practice (Fairest Cape Association, 1998; Rossiter & Kumana, 1995).

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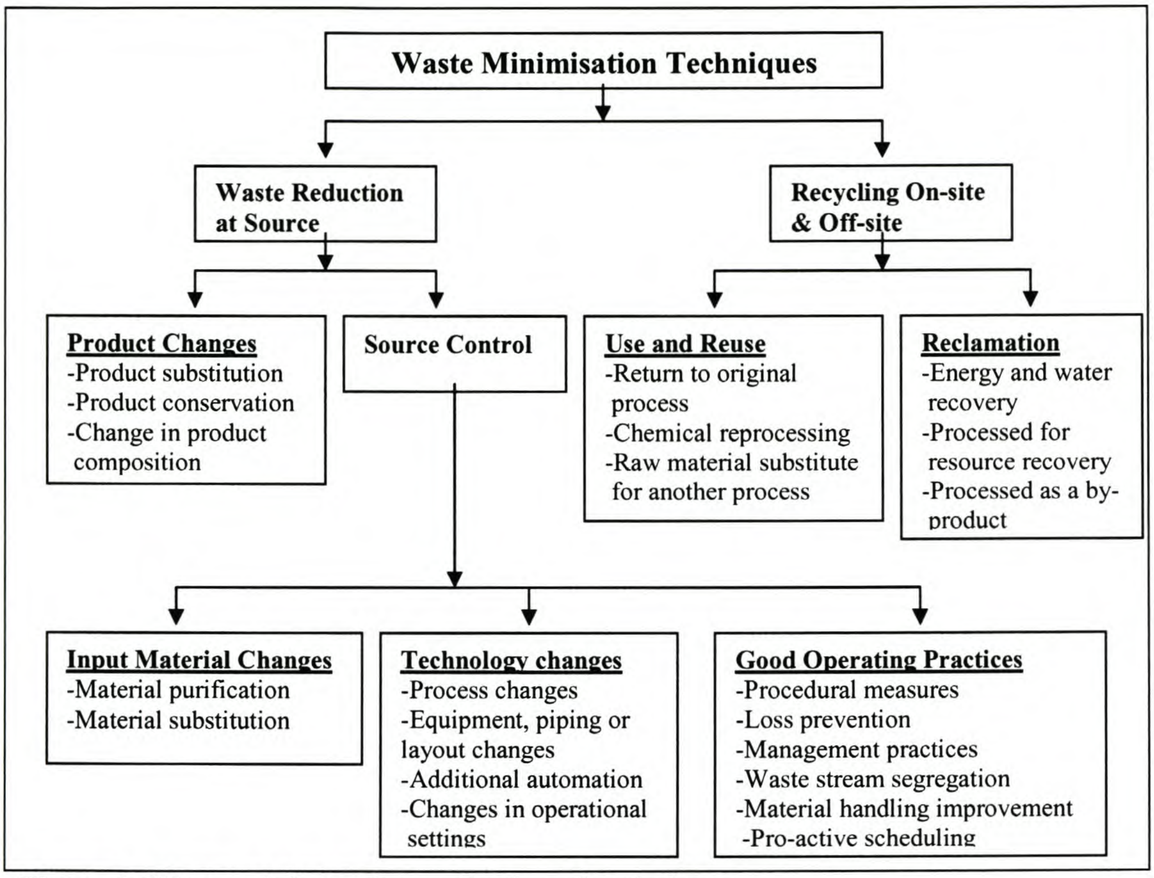

Figure 6: Waste minimisation methods and techniques

Source: South Africa (1994: 20)

The following subsections review the individual waste minimisation techniques in each of the two principal categories.

2.2.1 Methods of waste reduction at source

Technological changes for preventing or reducing waste at source fall into four general categories (as shown in Figure 6) which tend to be implemented in successive phases and in order of decreasing ease of implementation, namely product changes and source control, the latter including good practices (or improved housekeeping), input material changes and technology changes.

Product changes: Product changes are reformulations of final or intermediate products, performed by the manufacturer, in order to reduce the quantity of waste arising from their

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manufacture. Other objectives might include a change in a product's specification in order to reduce the quantity of chemicals used; a modification of the composition or final form of a product to make it environmentally sound; and changes to reduce or modify packaging. Product reformulation is one the more difficult waste minimisation techniques, and due to the proprietary nature of product formulations, specific examples are currently scarce (Jackson, 1991; Johannson, 1992).

Input material changes: This technique may also lead to a reduction in, or avoidance of, the formation of waste. Examples regarding a reduction in the hazardous nature of the wastes include substitution of chemical biocides with alternatives such as ozone; replacement of solvent-based paint, ink and adhesive formulations with water-based materials; substituting a more durable coating to increase coating life; increasing the purity of purchased raw materials to eliminate the use of trace quantities of hazardous impurities; replacement of hexavalent chromium salts in plating applications; and replacement of cyanide plating baths with less toxic alternatives. However, a possible problem with material changes is that they can have changes on the production process, product quality and waste generation (Crittenden & Kolaczkowski, 1995; South Africa, 1994).

Technology changes: Technological change is about process and equipment changes applied in order to reduce waste, mainly within the production environment. The changes involve the use of a new or modified process and hardware to lessen or prevent pollution. Examples include the introduction of new processes or equipment which produce less waste, i.e. 'clean' technologies; fundamental change to, or better control of process operating conditions such as flow rate, temperature, pressure and residence time to reduce waste and consume less raw materials and energy; redesign of equipment and piping to reduce the amount of material to be disposed of during start-ups, shutdowns, product changes and maintenance programmes; and the use of more efficient motors and speed control systems to reduce energy consumption (Johannson, 1992).

Good practice: Good operating practice, good housekeeping, good engineering and maintenance, which all involve operational improvements or administrative changes, can

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often be implemented relatively quickly to reduce waste. This technique is cost effective and reduces cost without incurring significant investment. Some examples of good practice are: a clear specification of good housekeeping and materials handling procedures; implementation of quality assurance techniques; regular auditing of materials purchased against materials used; avoidance of over-ordering; segregation of waste streams to avoid cross-contamination of hazardous and non-hazardous materials, and to increase recoverability of waste materials; reduction in the volume of waste by filtration, vaporisation, drying and compaction; improvement of maintenance scheduling, good record-keeping and procedures to increase efficiency; collection of spilled or leaked materials for reuse; and rescheduling of production to reduce frequency and number of equipment cleaning operations (Crittenden & Kolaczkowski, 1995).

2.2.2 Recycling

Recycling creates secondary raw materials which can, in most cases, be substituted for primary material in an environmentally sound manner. Recycling waste materials for reuse, use and reclamation may provide a cost-effective alternative to treatment and disposal of waste. However the reduction and minimisation of waste at source is the preferred option in the hierarchy of waste management practices, and recycling should only be considered if all other options for waste minimisation have been utilised to maximum potential (Ball, 1999).

The success of recycling depends on the ability to reuse waste materials by returning them to the originating process as a substitute for an input material; or the ability to use waste material as a raw material either on-site or off-site; or the ability to separate recoverable and valuable materials from the waste (reclamation). Successful reclamation therefore depends on the ability to separate recoverable and valuable materials from those low value materials which must be disposed of and treated in some acceptable way.

On-site recycling: The best and most efficient place to recover wastes is within the production facility. The best waste materials for recycling are: contaminated versions of processed raw materials, which can be used to reduce raw material purchases and waste

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disposal costs; lightly contaminated waste which can be used in other operations not requiring high purity materials; waste which has physical and chemical properties for other on-site applications; and the reuse of extracted water from diluted, high volume waste streams. Most on-site recycling processes will always generate some residue or waste which must be disposed of safely if it cannot be used further on-site (De Larderel, 1992).

Off-site recycling: Wastes may be considered for use or reclamation off-site when, equipment is not available on-site to do the job; not enough waste is generated to make on-site recycling cost-effective; and/or the recovered material cannot be used in the production process. Materials commonly reprocessed off-site by chemical and physical methods include oils, solvents, electroplating wastes, lead-acid batteries, scrap metal, food processing waste, bottles, plastic waste and cardboard (De Larderel, 1992).

The cost of off-site recycling depends on the purity of the waste and the market. Some materials generate income whilst others require payment to be taken off-site for recycling. A strong commitment is required from waste generators not only for upgrading waste material for sale or exchange, but also for finding markets and to conserve the environment (De Larderel, 1992).

2.2.3 Other methods

Reuse: Most wealthy societies have the tendency to produce more waste per capita and many used products end up in the waste stream before they have stopped to function effectively. Additional utilisation of resources would be minimised by exploiting opportunities for reusing waste streams on-site without any specific treatment. Some waste materials which may be by-products of reactions, and therefore not recyclable within the process, could be used as feedstock in other industrial processing operations or processed to recover constituents of value or other marketable products. One way of reusing waste would be by trading between companies which could be facilitated by waste exchange systems which transfer either information concerning the availability or need for waste materials or the waste materials themselves (Ball, 1999; Coleman, 1994).

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The longer-term sustainability aim centres on the design of much more durable products consisting of parts which can be easily replaced when needing repair or modernisation without scrapping the complete item. A change in consumer values is also preferred to one which rejects the replacement of useable products with the latest modern, redesigned product. This would lead to less products ending in the waste stream.

Reclamation: Reclamation involves the recovery of valuable material from the waste stream or to make waste material suitable for further reuse. Processing of this waste material for material or energy recovery can sometimes pose difficult problems for material handling because of the possible cross-contamination of different material. Additional material and energy consumption is involved and there will always be some waste residual. Material recovery by recycling is usually considered more energy-efficient than energy recovery through combustion and it avoids environmental impacts associated with the processing of raw materials. However, analyses of the life cycles of different products have indicated that mitigation of total environmental impacts may favour material destruction with beneficial energy recovery, as opposed to additional resource consumption in material reclamation processes (Taylor, 1993).

Energy recovery: The recovery of energy from waste is not only about incineration but can also include the deliberate generation of methane in digesters. Incineration with energy recovery has a part to play in the process of managing waste in the most sustainable manner, but cannot be developed in isolation and must be recognised as a method of reducing volume, not a means of disposal. In the waste management hierarchy, energy recovery is positioned below materials recovery, as any material which is incinerated is lost to the closed loop process. Waste can be burnt in a modern state-of-the-art incinerator in such a way as to minimise the environmental impacts, reduce the volume by 90 per cent and energy is produced in the process (Clark, 1995).

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2.3 Waste minimisation assessment methodology

The first step in a waste minimisation programme would be to set goals and time frames which are in line with a company's environmental management policy. The waste minimisation methodology is summarised in Figure 7.

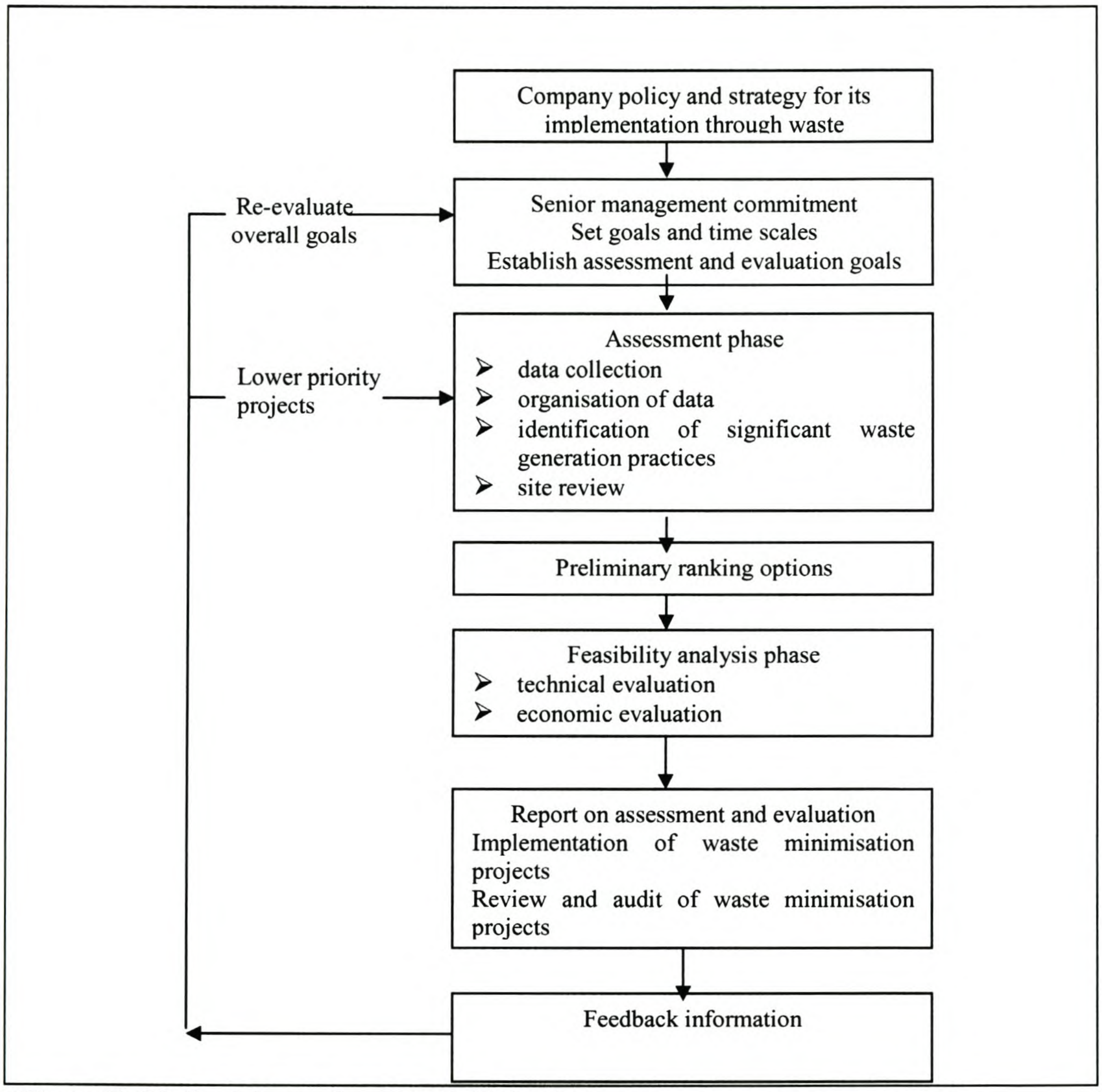

Figure 7: Methodology of waste minimisation

Source: Crittenden & Kolaczkowski (1995: 16)

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It is advisable for management to have measurable goals and times frames which can provide a basis for measuring processes during the auditing phase. Examples of such include:

- Waste emission levels and waste production quantities will be reduced by a certain percentage within a specified time.
- Realistic emissions and waste production level targets should be set annually. The goals should be flexible and adaptable to account for conditions encountered in actual practice.
- Define terms in such a way that they are understandable for implementation by management and goals that are flexible enough to motivate staff.

For a successful waste minimisation assessment and evaluation process, all players in a company should be actively involved in order to gain their interest, this should incorporate from top management to lowest ranking employee within the company. Each group should have direct responsibility or role to play in the process. A good understanding of the kinematics chemistry and chemical engineering of the process involved in the plant is required, hence it is sometimes necessary to consult specialists. In order to carry out a successful assessment (audit) phase, a waste production and minimisation data gathering exercise, which includes a site inspection or review which helps to understand the processes and to identify and characterise all waste streams, is required. The significance and importance of carrying out the waste tracking exercise is to develop a waste flow diagram for each plant and process which can provide a measurable mass balance between inputs and outputs (Crittenden & Kolaczkowski, 1995).

Chapter 2 has outlined the basic principles pertaining to waste minimisation, including concepts related to WM and WM methods. The WM methods range from source reduction methods, recycling and other WM methods at disposal of wastes. Finally the WM assessment methodology which is used to guide the assessment of current practice of industrial WM in Stellenbosch is introduced. This is discussed in detail in the next chapter.

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3. INDUSTRIAL WASTE MINIMISATION IN STELLENBOSCH: CURRENT PRACTICE

This chapter presents a review of environmental aspects of waste and waste management that are applicable elsewhere and that can be applied to the Stellenbosch industries. Subsection 3.1 initially reviews the current policy and legislation pertaining to waste management in South Africa, while the greater part of this subsection presents the results of the analysis of data on input material use, current waste quantities and environmental impacts in Stellenbosch based on the questionnaire survey. The waste minimisation methodologies practised in Stellenbosch are discussed in sub-section 3.2.

3.1 Industrial waste, waste minimisation and the environment in Stellenbosch

The World Commission report on environment and development shows that measures to reduce, control and prevent pollution need to be greatly strengthened in both developed and developing countries. Many of the efforts are focussed mainly on pollutants of global concern. In 1992, the United Nations Conference on Environment and Development established an agenda (Agenda 21) for world action concerning the environment and increased international efforts towards sustainable development. The South African government (after 1994) in its efforts to meet the goals of Agenda 21, has developed an Integrated Pollution and Waste Management Policy for pollution prevention and waste minimisation in South Africa (South Africa, 1999b).

South Africa is emerging from a period of unsustainable and inequitable development and there is a need for such a policy. In order to move towards development that is economically, socially and environmentally sustainable, all sectors will have to undergo a number of important transitions. A priority is a transition towards accelerated industrial development while using cleaner technologies and production methodologies (South Africa, 1998a).

In the past there has been legislation in South Africa which attempts to address environmental and human health threats by pollutants. However, there has been a number of limitations to these regulations. The most fundamental right in the context of

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integrated pollution and waste management is the environmental right (Subsection 24) which provides that:

"Everyone has the right

(a) to an environment that is not harmful to their health or well-being: and

(b) *to have the environment protected, for the benefit of present and future generations through reasonable legislative and other measures"* (South Africa, 1996: 11).

The other relevant legislation pertaining to waste minimisation is the National Environment Management Act No. 107 of 1998 (s2) which states that:

"The principles set out in this section apply throughout the Republic to the action of all organs of state that may significantly affect the environment and

(a) Sustainable development requires the consideration of all relevant factors including that waste is avoided, or minimised and reused or recycled where possible and otherwise disposed of in a responsible manner" (South Africa, 1998a: A-461).

During the participative research process conducted in the development of the Integrated Pollution and Waste Management policy three key issues were identified i.e. water, air and land as well as waste as major source of pollution. Key issues relating to pollution and waste are determined to be due to improper waste management, fragmented legislation and ineffective enforcement. Absence of integrated waste management options and concerns expressed in this regard include the lack of waste avoidance, minimisation and cleaner production technology initiatives. Also of concern is the current lack of regulatory initiatives to manage waste minimisation, with the potential for reducing the hazardous waste problems. Internationally, integrated waste management is recognised as addressing these criticisms by focusing on four recognised steps i.e. waste avoidance (prevention and minimisation), resource recovery (recycling and reuse), waste treatment and disposal (South Africa, 1998b).

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The South African government believes that pollution prevention is supposed to be an everyday activity and this can eliminate costly and unnecessary waste and can promote sustainable development. The shift to prevention in South Africa will minimise and/or avoid the transfer of pollutants from one medium to another, minimise health risk and accelerate the reduction and/or the elimination of pollutants (South Africa, 1998b).

The present policy on waste management takes into consideration domestic, commercial, agricultural, mining, industrial, metallurgical, power generation, nuclear, medical and hazardous waste, as well as litter. According to South Africa (1998b), issues which will be considered when implementing the Integrated Pollution and Waste Management policy, include waste avoidance, minimisation, recycling, reuse, treatment, handling, storage and final disposal of waste. The Department of Environmental Affairs and Tourism (South Africa, 1998b), will adopt a functional approach to integrated pollution and waste management, and will also conduct the regulation thereof (see Figure 8).

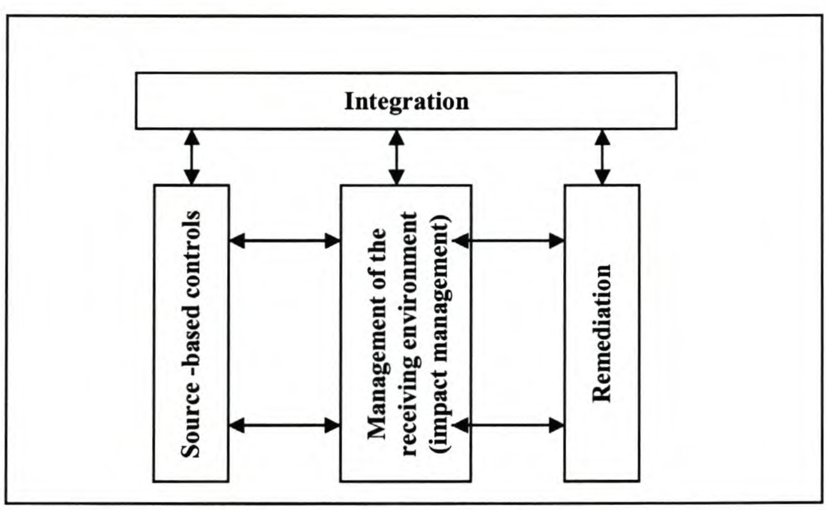

Figure 8. A functional approach to integration of pollution and waste management
Source: South Africa (1998b: 34)

The government has set goals and supporting objectives for achieving the vision of integrated pollution and waste management over five to ten years starting from 1999. The goals are:

- Goal 1: Effective institutional framework and legislation

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- Goal 2: Waste minimisation, impact management and remediation
- Goal 3: Holistic and integrated planning
- Goal 4: Participation and partnerships in integrated pollution and waste management governance
- Goal 5: Empowerment and environmental education
- Goal 6: Information management
- Goal 7: International cooperation.

The government has also initiated a process of formulating a national waste management strategy, which includes implementation strategies to give effect to the integrated pollution and waste management policy and a number of action plans. The strategy also includes the promotion of holistic and integrated pollution and waste management through pollution prevention, minimisation at source, impact management and remediation. The government (South Africa, 1998b) has developed a national waste management strategy which is to:

- develop mechanisms to set targets to minimise waste and pollution at source;
- develop mechanisms to prioritise pollutants requiring prevention control by utilising a risk-based approach to assess the impact on the environment;
- develop mechanisms to set up information systems on chemical hazards and pollution releases and the introduction of a system to trace transportation and disposal of waste material; and
- develop mechanisms to promote cleaner production technologies.

According to South Africa (1998b), pollution and waste avoidance, prevention and minimisation can be achieved by:

- adhering to mechanisms to ensure appropriate design parameters, optimising operating procedures and good housekeeping for all waste generating processes; and
- identifying mechanisms by means of risk assessment for situations where accidents and spills can cause unscheduled waste emissions, whether it is at a facility or during transport.

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It seems that South Africa had no national policy in relation to waste minimisation at the time the study was commissioned (1999), although the need to implement such a strategy has been acknowledged by most role players. There is still continued dependence on the technology of end-of-pipe treatment and disposal to manage waste. The literature review of the South African situation in industrial waste management has reinforced the premise that problems of effective waste management by the manufacturing industries require specific attention (Semoli, 1999). The following subsections are intended to review what is actually happening in a sample of Stellenbosch's manufacturing plants concerning waste minimisation.

3.1.1 Use of input/raw materials

Today, environmental impacts mean money and can be very costly. If company buys raw/input materials, including energy and water, and pays to have waste treated and disposed of, all this affects the production costs of a product. The attention given to raw/input material losses during production and the waste and emissions produced, all of which will affect the environment, indicate the efficiency of an operation and whether it is given full value for money hence this is one of the reasons why waste minimisation is so important to all factories (Bethlehem & Goldblatt, 1999).

One of the most important inputs of a factory is the primary input materials. These materials can differ from factory to factory and come from different input material sources. Sometimes one factory uses the product of another factory as input material and this is known as process linkage (Erwin & Healy, 1990). Table 2 shows the types of input materials, the products, as well as number of employees, in each of the ten surveyed factory types.

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Table 2. Inputs and products of surveyed factories in Stellenbosch, 1999

SIC major group	Factory description	Material inputs	Products	No. of employees	Number of surveyed factories
302	Dairy products	milk	speciality and spreadable cheese, cream, whey	180	1
304	Other food products	water, oil, spices, fruit	marinades, sauces, fruit	112	2
305	Beverages	grapes, bulk wine, wine spirits	wine	777	2
311	Textiles	fabric, boxes	industrial clothes, thread	34	1
317	Footwear	leather	men's shoes	100	1
322	Wood, cork & plaiting material	wood, chipboard, timber, resin, awnings, shutter boards, laminated products, old furniture components	chipboard, roof trusses, furniture, wine barrels, shutter boards, awnings	604	6
325	Basic chemicals	undisclosed	undisclosed	3	1
342	Non-metallic mineral products	PVC, placticisors, fillers, pigments, stabilisers	vinyl compounds	30	2
355	Fabricated metal products, metalwork service	steel, cast iron, mild steel, stainless steel, aluminium	burglar bars, safety gates, furniture, packaging machines, machinery parts, cast iron, drying tunnels, crate tippers	98	11
626	Maintenance & repair of motor vehicles	nuts, bolts, brake shoes & pads, oxyacetylene welding	exhaust systems, shock absorbers, tyres, tow-bars, hydraulic cylinders	113	14
Total				2051	41

Source: Industrial survey, 1999

Table 2 does not indicate much evidence of process linkages among Stellenbosch factories. The only examples which can be cited are where cast iron is used as an input material by some factories in the fabricated metal products (SIC 355) and is being manufactured by some of factories in the same category. Old furniture components are

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also used as material inputs in a wood, cork and plaiting material factory (SIC 322) and furniture is reused by the same factory type and also by the metal products manufacturers (SIC 355). The basic chemicals factory (SIC 325) disclosed neither the materials used nor the products produced. The number of employees in each factory was also recorded to demonstrate the importance of these factories in terms of job creation. This is basically to demonstrate that even though there are some bio-physical environmental problems associated with these factories at the same time the socio-economic environment is of the local community is uplifted. The following subsection 3.1.2 outlines the composition and quantities of waste produced by different categories of factories.

3.1.2 Overview of waste generation

Information about the types of waste produced was obtained by asking the respondents to indicate the kinds of waste generated by their factories. This is important for an effective waste management strategy because different types of waste are managed differently. Three options were given and respondents were required to indicate the appropriate option for their factories. Figure 9 indicates that 71 per cent of the factories produce mainly solid waste, hence confirming this study's focus on the minimisation of solid waste. The remainder produced either mostly liquid waste (12%) or solid and liquid waste (17%) in more or less equal amounts. Because solids and liquids are measured in different units, these are simply estimates.

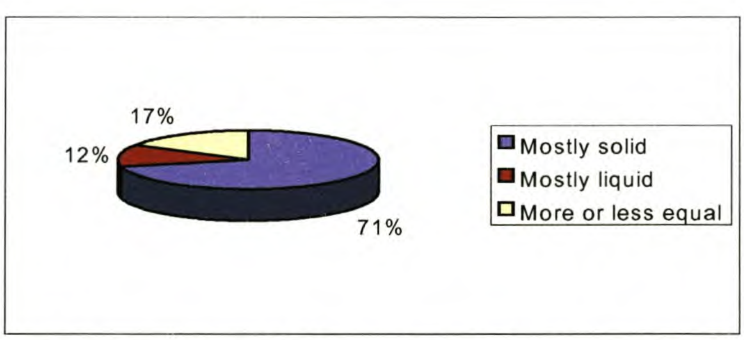

Figure 9. Types of waste produced in by factories in Stellenbosch, 1999

Respondents were asked to indicate the quantity and types of solid waste produced by their factories. The factories were grouped according to the South African Standard

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Industrial Classification (SIC). The total quantities of solid waste were added together in each category and summarised in Table 3, where it can be seen that the beverage factories (wine cellars) produced more solid waste than the combined total of all other factories. The average total solid waste produced by the beverage producers per year was 9 600 tons or 4 800 tons per factory. The reason for this high waste production might be that the beverage factories are large-scale enterprises requiring high input material and about thirty per cent of that is converted into solid waste. The factories are the extremely important as they are they employ the largest number of workers in total (777). This is followed by the six wood, cork and plaiting material factories, which produced a total of approximately 97 tons (16 tons per factory) of waste every year and is the second most important source of employment with six hundred and four (604) employees. The third largest waste-producing category of factories is the dairy products factory which produces 11.7 tons of waste every month and has the third highest number of employees (180). From the results discussed above and those given in Table 3, it can be deduced that even though some of these factories produced large quantities of waste they also play a significant role in job creation. However there is no correlation between the number of employees per factory and quantity of waste produced.

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Table 3. Annual solid waste quantities produced and generation by factories, Stellenbosch 1999

SIC major group	Factory description	Total waste produced (tons) per year	Number of factories	Average solid waste per factory (tons) per year	Average % of total waste disposed of on-site per year
302	Dairy products	11.7	1	11.7	0
304	Food products	2.5	2	1.25	50
305	Beverages	9 600	2	4 800	0
311	Textiles	0.5	1	0.5	53.3
317	Footwear	1.1	1	1.1	0
322	Wood, cork & plaiting material	97	6	16.2	42.6
325	Basic chemicals	1.5	1	1.5	0
342	Non-metallic mineral product	2.8	2	1.4	0
355	Fabricated metal products, metalwork service	3.57	11	0.32	34
626	Maintenance & repair of motor vehicles	8.78	14	0.63	66.6
Total		9 729.45	42	483.46	24.65

Source: Industrial survey, 1999

There are some anomalous cases, like the basic chemical factory which produces about 1.5 tons of solid waste per year and at the same time does not play a major role in job in creating job opportunities, these factory employs on only 3 persons. The textile and the footwear factories also play a major role in creating jobs having 34 and 100 employees respectively. The textile factory produces about 0.5 tons of solid waste per year, where as the footwear factory produces about 1.1 tons of solid waste every year.

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Table 3 also shows the percentage of waste disposed of on-site. The maintenance and repair of motor vehicles has the highest percentage (66.6%) of waste disposed of on-site, followed by the textiles factory with 53.3 per cent, then food products with 50 per cent of waste disposed of on-site. This category (SIC 626) does not produce any products but buys ready-made parts which are used to replace worn-out items, hence the high production of waste material. As for the other factories, they are mainly producers of products and the waste is mostly by-products. The percentages were estimations made by the factory managers. No concrete conclusion can be made other than that the firms have different operations, hence the big difference in waste production.

It was also necessary to investigate who is responsible for collecting waste from the factories as it is an important aspect of the waste management cycle. Figure 10 indicates that most (45%) of the factories collect and remove their waste from their premises themselves, the reason being that the costs of doing so are lower than by other means. Another 29 per cent of factories have their waste collected by the municipality, which is cheaper than using the services of private contractors, while over 24 per cent of the factories have their waste collected by private contractors like Waste-Man and Waste-Tech, which transport the waste to Cape Town to their own landfill sites. The transport of the hazardous waste, which cannot be dumped at the Stellenbosch dump site, is expensive. The reason for different collecting preferences is probably cost driven. Some (2%) factories did not disclose who collects their waste.

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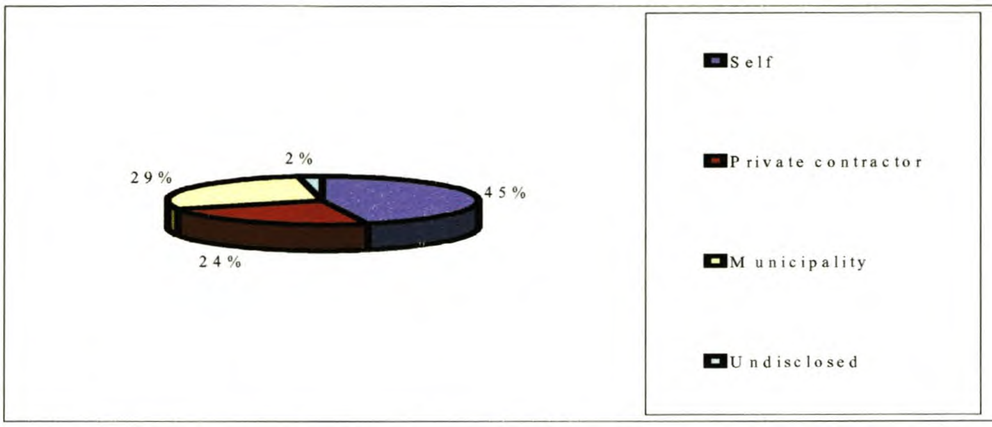

Figure 10. Methods of collection of industrial solid waste in Stellenbosch, 1999

Table 4 summarises the waste disposal methods used by the 11 factories which responded to the question. All of these factories dump their waste at the Stellenbosch dump site and none of the 11 factories practice incineration or any other method of waste disposal. The rest of the respondents (31) did not disclose the disposal method employed by their factories.

Table 4: Disposal methods of industrial solid waste in Stellenbosch, 1999

Method	No. of cases	Percentage
Disposal at dumping site	11	26
Incineration	unknown	unknown
Other	unknown	unknown
No response	31	74
Total	42	100

Source: Industrial survey, 1999

From Figure 10 and Table 4 it can be concluded that the surveyed factories in Stellenbosch predominantly make use of off-site waste disposal facilities. Again the waste is disposed of at dump sites managed by the municipality and private contractors.

3.1.3 Environmental impact

The respondents were also asked to indicate whether they experience any environmental problems with the waste prior to collection on-site. From Figure 11 it is evident that more than four out of five respondents do not experience any environmental problems. Fewer than one in five do experience problems. This indicates that a vast majority claim not be

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experiencing any problem which was not the case observed during site visits. Almost all the visited sites were seen to be causing environmental problems ranging from odours, dust, eyesores and occupation of space.

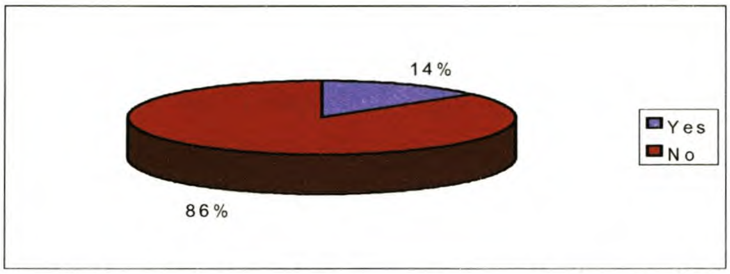

Figure 11. Factories experiencing environmental problems caused by their waste in Stellenbosch, 1999

A problem experienced by factories is the bad odours that result when waste is not removed within a few weeks. It is mainly the beverage factories (wineries) that experience this problem which is caused by rotting grape skins left over after making wine. This problem of bad odours was also experienced by neighbouring factories as they indicated that they experience bad odours emanating from other factories. The respondent for the dairy products factory reported experiencing "bad odour and bacterial contamination". The wood, cork, straw and plating materials factories experience boiler emissions, dust and noise, mainly from the timber factories when sawing is in progress.

Even though the findings indicate that only a few factories (14%) experience environmental problems, there is a need by all stakeholders to take preventative measures into consideration. The next subsection focuses on the extent to which waste is being minimised.

3.2 Waste minimisation practices

A report by the Department of Environmental Affairs (South Africa, 1999a) indicates that little waste minimisation is practised by South African industries. Apparently there is little appreciation for the benefits of waste minimisation, which have been identified as savings in input material, utility, and waste management costs. Waste minimisation

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efforts which are reported include backfilling of mining overburden, reprocessing of metallurgical waste for the recovery of valuable materials and recycling of tar and pitch waste from petrochemical operations (South Africa, 1999a). These activities are associated mainly with large-scale manufacturers who have economies of scale and technological and financial resources to operate on-site waste treatment and disposal facilities.

Small- and medium-sized plants are more dependent on off-site waste treatment and disposal facilities. Solid waste is disposed of at dump sites managed by local municipalities and private contractors, as is the case in Stellenbosch (see section 3.1). Because small- and medium-size undertakings make a significant contribution to waste quantities, it is appropriate to conduct a study of waste minimisation in Stellenbosch. Figure 12 portrays the degree of familiarity with the concept of waste minimisation revealed by the respondents in Stellenbosch. The figure indicates that about one out of three respondents was not familiar with waste minimisation.

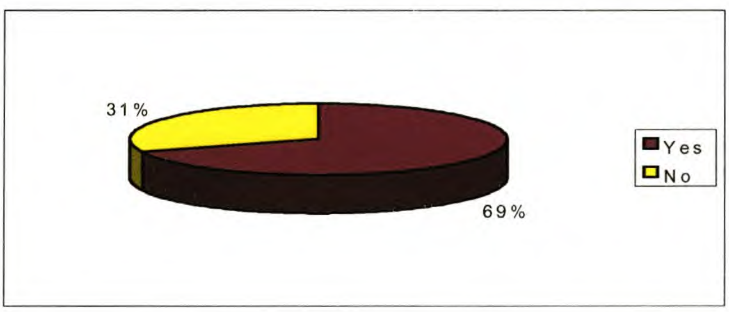

Figure 12. Familiarity with the concept of waste minimisation among respondents from factories in Stellenbosch, 1999

It is not surprising that there is a relatively high percentage (31%) of respondents who are not aware of the waste minimisation concept as the literature (Fairest Cape Association, 1998) indicates that South Africa is still behind developed countries with regard to waste minimisation development. This is an indication that the South African government needs to promote waste minimisation in industries, first by educating all role players and then by introducing legislation which will promote waste minimisation to its full potential.

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Respondents were also asked to rate the importance of waste minimisation as a contribution to industrial solid waste managed by their factories. Figure 13 shows that more than half of the respondents regard waste minimisation as highly important, a quarter see it as very important, while only seven per cent regard it to be not important. About 12 per cent of the respondents say that waste minimisation is important.

These results show that there is support for waste minimisation and this signifies that should action be taken to help the industries to minimise waste, there will be commitment from industry. The seven per cent who regard waste minimisation as not important might be the respondents who are not aware of the environmental impacts or any other consequences caused by waste.

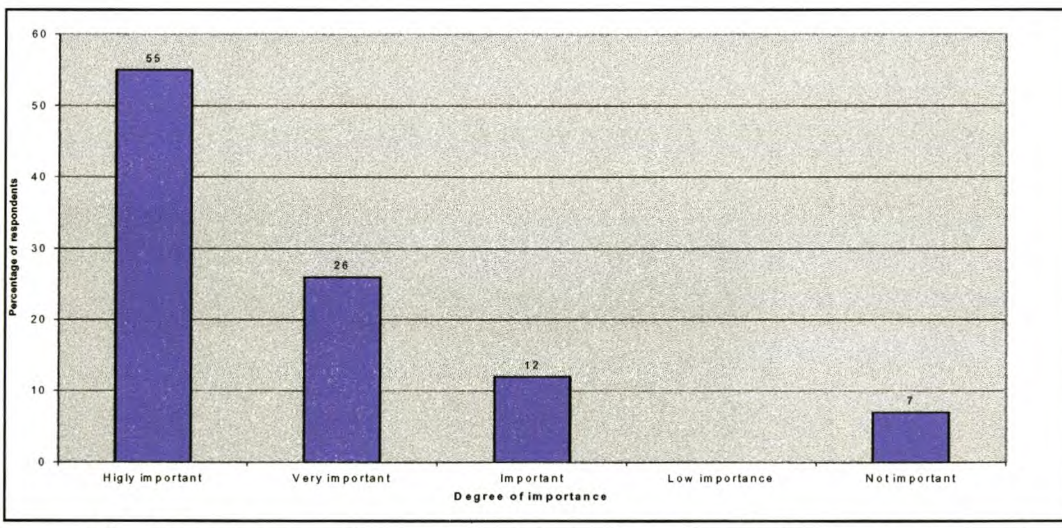

Figure 13. Importance of waste minimisation to factory management in Stellenbosch, 1999

Given the perceptions and familiarity on WM discussed above, the next subsections will determine the level of implementation of WM in the Stellenbosch industrial areas.

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3.2.1 Source reduction

Source reduction is regarded as the best method for minimising waste before it is generated. Table 5 sets out the methods of source reduction currently practised in Stellenbosch and the proportion of factories currently (1999) practising waste minimisation by source reduction.

Table 5. Source reduction methods of waste minimisation practiced in Stellenbosch, 1999

Factory type (SIC)	Option			Year when first factory started to practice	Average % reduction of weight, bulk or volume reduced
	Source reduction				
	ERC	PRC	MRC		
302 Dairy products	0/1	0/1	1/1	1996	30
304 Food products	0/2	2/2	2/2	1998	5
305 Beverages	0/3	0/3	0/3	unknown	unknown
311 Textiles	0/1	0/1	0/1	unknown	unknown
317 Footwear	0/1	1/1	0/1	unknown	unknown
322 Wood, cork & plaiting material	2/6	0/6	3/6	1997	50
325 Basic chemicals	0/1	0/1	1/1	1999	60
342 Non-metallic mineral product	0/2	1/2	0/2	1994	50
355 Fabricated metal products, metalwork service	5/11	8/11	7/11	1995	32
626 Maintenance & repair of motor vehicles	0/14	0/14	0/14	unknown	unknown
	16.7 %	28.6%	33.3%		

Source: Industrial survey, 1999
ERC = Equipment-related change
PRC = Personnel-related change
MRC = Material-related change

Three different types of source reduction were being practised in Stellenbosch in 1999, namely equipment-related change, personnel-related change and material-related change. Only two types of factories practice waste minimisation by the equipment-related change

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method. These are the factories involved with the manufacturing of wood, cork, straw and plating materials (SIC 322) and two of the six factories in this category employed this technique. The manufacturer of other fabricated metal products and metal service activities (SIC 355) also practised the equipment-related change method and 5 of the 11 factories in this category employed the technique. The results were expected because it is more expensive to employ the equipment-related change method than other methods, as this method requires changing certain equipment used in the factories. Only 17 per cent of the surveyed factories practice ERC methods.

The personnel-related change method is practised by four of the ten different types and twelve of the forty-two factories. This method pays attention to good operating practice, i.e. good housekeeping, good engineering and good maintenance, which involve operational improvement or administrative changes to be implemented relatively quickly to reduce waste. The categories of factories which practise this method are food products (SIC 304) where all the factories employ the method, footwear (SIC 317), non-metallic mineral products (SIC 342) and fabricated metal products (SIC 355). Nearly 30 per cent of the factories practice this method.

The material-related change method is the most common and is used by five factory (14 of 42 factories) types, namely those manufacturing dairy products (SIC major group 302), food products (SIC 304), wood, cork, straw and plaiting materials (SIC 322), basic chemicals (SIC 325) and fabricated metal products (SIC 355). Thirty three per cent of the factories practice this method. This MRC result is not surprising as the factories prefer to use the input material which can be economically viable since less input material will be used and profits can be increased. The manufacturers of fabricated metal products (SIC 355) are the only ones employing all three methods of source reduction. Three factory types do not practise waste reduction, namely manufacturers of beverages (SIC 305), spinning, weaving and textiles (SIC 311) and maintenance and repair of motor vehicles (SIC 626). The beverage manufacturers experience environmental problems with their waste while still on-site, yet they do not practice waste reduction at source. The factories

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involved in maintenance and repair of vehicles cannot practice waste reduction at source since they do not manufacture.

The respondents were further asked when they started practising reduction at source and what percentage reduction of weight, bulk or volume reduction waste they had achieved. The first factory type to employ waste reduction at source in Stellenbosch is the of non-metallic mineral products group (SIC 342) which began this in 1994 and have managed to reduce the volume of their waste by half. This shows that there is room for improvement in the existing source waste reduction, as the only method of source reduction they employed was personnel-related change. Table 5 shows that the highest bulk waste reduction rate of 60 per cent (average) was attained by the basic chemicals (SIC 325) manufacturing plant, which only started to employ the method in 1999. Source reduction by material-related change seems to be effective since there was a noticeable change in the quantity of waste reduced within a short period of time. The manufacturers of products of wood, cork, straw and plating materials also reduced their waste by half since starting to use the equipment-related and material-related change methods in 1997. However, more effort still needs to be made to reduce waste at greater rates. The manufacturers of fabricated metal products (SIC 355) reduced their bulk waste by one third on average since the implementation of all three source reduction methods in 1995. This suggests and confirms that the efficiency of the method used can sometimes rely on the other factors such as commitment from the management. The single dairy products (SIC 302) factory, which implemented the material-related chance method in 1996, reduced the bulk of waste by 30 per cent. By employing other source reduction methods this figure could be improved further. From the evidence in Table 5 it can be concluded that the material-related change method is the most commonly and effectively used method by manufacturing plants sampled in Stellenbosch.

Figure 14 illustrates the percentage of sampled factories of each type which practise waste minimisation by source reduction in Stellenbosch. There is full participation in source reduction by the single factory in each of the categories manufacturing dairy products (SIC 302), footwear (SIC 317) and basic chemicals (SIC 325). Fifty per cent of

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the respondent factories in the category wood products, cork, straw and plating materials (SIC 322), practice waste minimisation by source reduction. One of the two food products (SIC 304) factories and one of the two non-metallic mineral products (SIC 342) manufacturers participates in waste minimisation by source reduction. Only nine per cent of the sampled fabricated metal products (SIC 355) factories participated in source reduction. Seven per cent of the vehicle maintenance and repair businesses indicated that they participate in source reduction, but they could not disclose the method they employ. On the other hand there is zero participation by some the factory types, namely beverages (SIC 305) and textiles (SIC 311). The most likely WM methods to be used by these factory types are the technology changes and the good operating practices but they are not practised in this case.

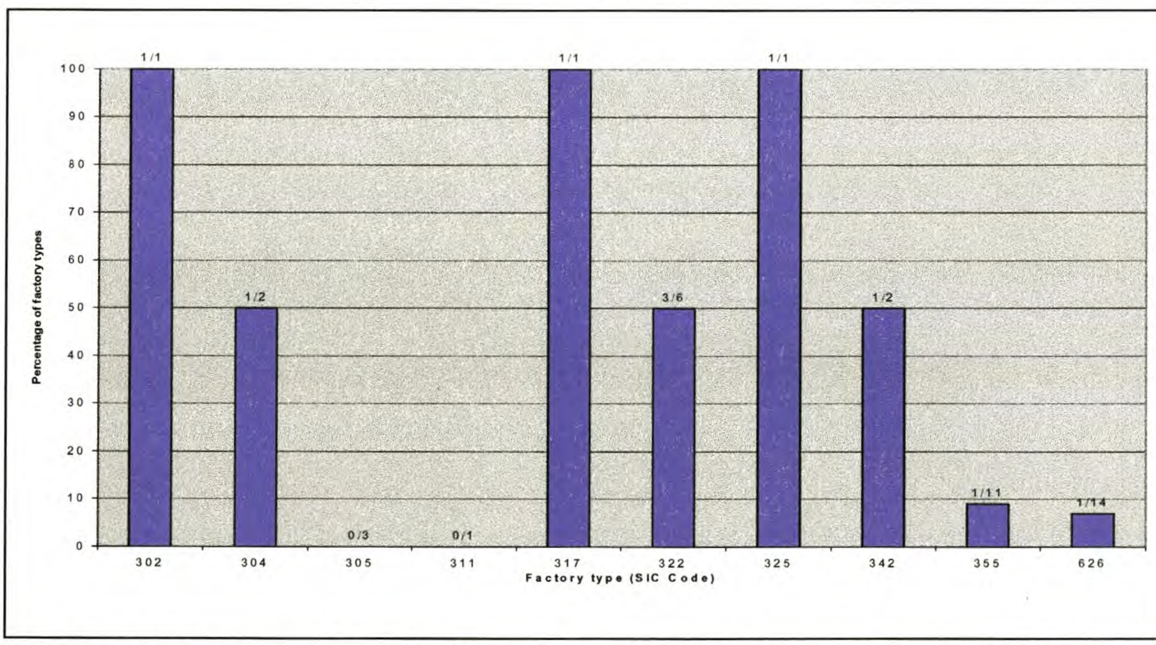

Figure 14. Number of factories practising waste minimisation by source reduction in Stellenbosch, 1999

The results given in Table 5 show that there is potential for more waste minimisation by source reduction in Stellenbosch. What is needed is promotion of WM by the government and increased commitment from the management of all factories. Figure 14 emphasizes that there are still many factories (32 out of 42) that do not participate in reduction of

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waste at source, hence measures should be instituted to see that all factories participate in waste minimisation. Another common method of waste minimisation that was developed before source reduction is recycling of waste materials and this is discussed below.

3.2.2 Recycling and/or reuse

Recycling, reuse and reclamation of waste materials further reduce the quantities of waste which have to be disposed of and also provide a cost-effective alternative to waste minimisation. Table 6 shows the recycling and/or reuse methods of waste minimisation used in Stellenbosch and the year of implementation. Figure 15 illustrates the percentage of factories which participate in recycling and/or reuse in each category of factory.

Table 6 shows that factories in 27 of the 42 (64%) factories practice recycling by selling waste material for recycling by other companies or for reuse by other factories for other purposes. Eight of the ten SIC categories employ this method. This reasonably high frequency is not surprising because recycling is the simplest method of waste minimisation and does not involve costs but, in fact, provides an income from selling the recyclables. The business also saves the expensive disposal costs. Two factory types do not sell or reuse their recyclables, namely the spinning, weaving and finishing textiles (SIC 311) and basic chemicals (SIC 325) categories. These factories produce waste materials which are non-recyclable and toxic. Another reason for the spinning, weaving and finishing textiles factory not selling waste is that there is no market for their waste that is recyclable.

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Table 6. Options for recycling and/or reuse of industrial waste minimisation options in Stellenbosch, 1999

Factory Type (SIC)	Option: Recycling and/or reuse		Year when started practising	Per cent (%) sold for recycling/reuse
	MS	MUFLQP		
302 Dairy products	1/1	0/1	1995	5
304 Food products	2/2	2/2	1997	20
305 Beverages	2/3	0/3	unknown	100
311 Textiles	0/1	0/1	unknown	unknown
317 Footwear	1/1	1/1	1995	unknown
322 Wood, cork & plaiting material	4/6	3/6	1980	unknown unknown
325 Basic chemicals	0/1	0/1	unknown	unknown
342 Non-metallic mineral product	1/2	1/2	1992	50
355 Fabricated metal products, metalwork service	7/11	5/11	1996	28
626 Maintenance & repair of motor vehicles	9/14	0/14	1994	unknown
Total	64.3%	28.6%		

Source: Industrial survey, 1999
MS = Material(s) sold
MUFLQP = Material(s) used by firm for lower quality purpose

A method of recycling which stood out involves the same firm using materials for lower quality purposes. Twelve of the 42 factories in the manufacturing categories practice this method. The method is commonly used because it saves on the cost of buying raw materials that can be supplemented by waste materials. Some of the factories buy waste material inputs from as far away as Johannesburg and still save costs e.g. non-metallic mineral product factory, Vinaco PVC Processors. The quality of such products is usually lower hence there is a need for market assurance. The factories that do not reuse their waste materials are those manufacturing dairy products (SIC 302), beverages (SIC 305), basic chemicals (SIC 325) and those involved with spinning, weaving and finishing textiles (SIC 311) or maintaining and repairing motor vehicles (SIC 626). The reason for these categories not reusing their reusable waste is that these waste materials cannot be

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used in the particular factory but may be used by another factory for a different purpose. For example, the grape skins from the wine cellars can only be used as organic mulch in agriculture and the worn-out parts from motor vehicles cannot be used directly by the garages but can be sold to recyclers and second-hand parts dealers.

Table 6 shows that factories that manufacture products from wood, cork, straw and plaiting materials first implemented waste minimisation by recycling as long ago as 1980. This contrasts with source reduction where the first waste minimisation method was only implemented in 1994. This emphasis the point that waste minimisation by source reduction is a newer concept, which is still in a developmental stage and needs more attention. The second factory to implement recycling is a manufacturer of non-metallic mineral products (SIC 342) in 1992. There is a long time difference between when the first and second factory implemented recycling. The reason for this difference might be the date of establishment of the different factories or it may depend on the understanding among management of environmental issues. According to Table 6, 100 per cent of the waste from beverages factory (SIC 305) is sold. This implies that all their recyclable waste is sold, which may be possible as Stellenbosch is a wineland area with many wine farms and the waste from beverage factories may be used as an organic mulch and some of it may be sold to other places in South Africa. The second highest reduction of waste volume by recycling occurs in the non-metallic mineral products (SIC 342) industry where 50 per cent (average) of the bulk volume of waste is sold. This is followed by the factories making fabricated metal products (SIC 355) and food products (SIC 304), with 28 per cent and 20 per cent (average) sale of recyclable waste respectively. The dairy products firm (SIC 302) sells only five per cent of its bulk waste, while the footwear (SIC 317) and wood materials (SIC 322) factories and the maintenance and repair of motor vehicles (SIC 626) businesses could not disclose the quantity of waste sold for recycling purposes, as they do not keep records.

Figure 15 illustrates the percentage of factories within each category that participated in recycling of waste materials. There is 100 per cent participation in recycling and/or reuse by the following factory types: dairy products (SIC 302), food products (SIC 304),

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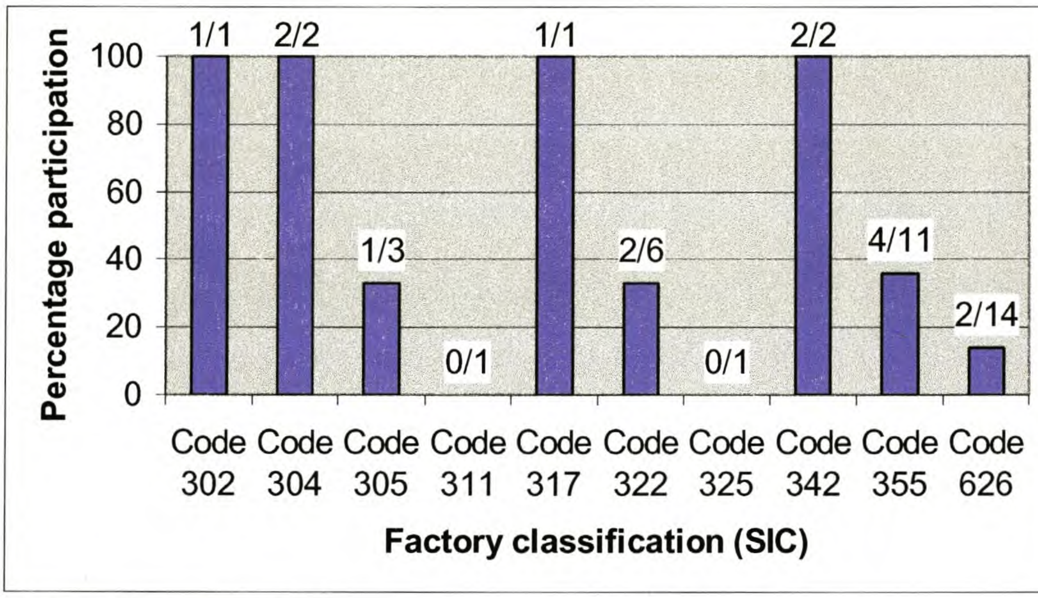
footwear (SIC 317) and non-metallic mineral products (SIC 342). About one in three of the beverages (SIC 305) and wood, cork and plaiting material (SIC 322) factories practise WM. Four of the eleven fabricated metal products (SIC 355) factories practise WM. Only two of the fourteen maintenance and repair of motor vehicles (SIC 626) factories participate in WM. There is no participation by the spinning, weaving and finishing of textiles (SIC 311) and basic chemicals (SIC 322) factory types.



Source: Industrial survey, 1999

Figure 15. Factories practising waste minimisation by recycling and/or reuse in Stellenbosch, 1999

From Tables 5 and 6 it can be deduced that waste minimisation is not developed to its full potential in Stellenbosch. Comparison of the tabulated results makes it possible to deduce that waste minimisation by recycling and/or reuse is the dominant practice in Stellenbosch. There are more factories that participate in recycling and by comparing Figures 14 and 15 this is clearly illustrated. The tables also reveal that the first method of waste minimisation to be employed in Stellenbosch is recycling and/or reuse and that there is a greater reduction of waste volume by source reduction, suggesting that source reduction is the most efficient waste minimisation method where possible to employ.

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3.2.3 Other methods

This section reports briefly on other forms of waste minimisation practiced by factories in Stellenbosch. The respondents were asked whether they were aware of other form(s) of solid waste minimisation practised by other factories in Stellenbosch.

Figure 16 shows that 62 per cent of the 42 respondents were not aware of any other factories in Stellenbosch practising other forms of waste minimisation, while 24 per cent did not respond to the question.

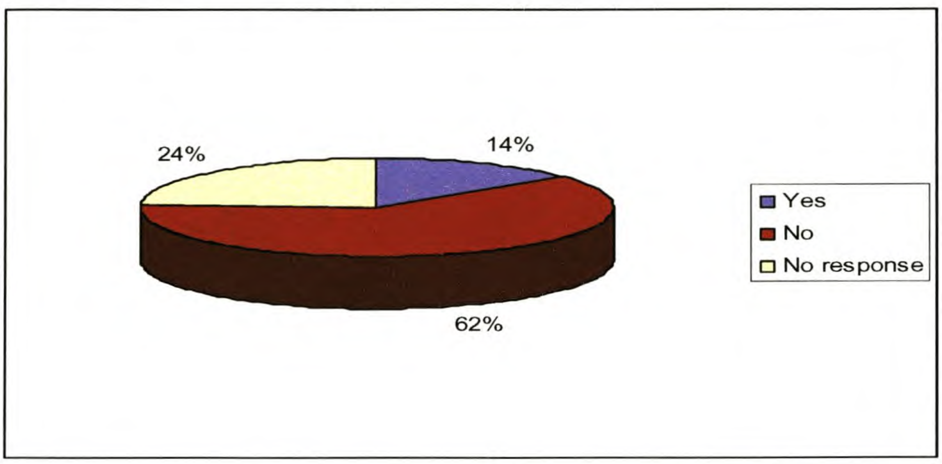

Figure 16. Awareness of other forms of solid waste minimisation practised by other factories in Stellenbosch, 1999

The 14 per cent of respondents who were aware of other factories currently practising other forms of waste minimisation mentioned Mondi Timbers, Vinaco and PG Bison. None of the respondents mentioned the method(s) employed by these factories. These results suggest that there is little awareness of waste minimisation in Stellenbosch and this is probably influenced by lack of exposure or ignorance, as one the respondent said "I am responsible for my own company." Such sentiments are confirmed in the next chapter where it will be reported that most of the respondents would be willing to participate in waste minimisation if improved methods of waste minimisation were to be brought to their attention.

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From the findings in this chapter it can be deduced that waste minimisation is currently at the beginning of its developmental stage in Stellenbosch and there is very little awareness regarding WM. Again, from the findings it can also be deduced that the commonly employed method of WM is recycling by means of selling the recyclable products, this is the less complicated method of waste minimisation. Finally, it can be concluded that there is a need or potential for developing other forms of WM and this investigated in the next chapter.

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4. POSSIBILITIES FOR INDUSTRIAL WASTE MINIMISATION IN STELLENBOSCH

The purpose of this chapter is to apply the waste minimisation methodology described in section 2.3 on the basis of the survey results reported in Chapter 3. In this chapter the potential for and the industries' perceptions of waste minimisation are also discussed. The constraints on and the suitability of waste minimisation in Stellenbosch are also assessed.

4.1 Applying the waste minimisation assessment methodology in Stellenbosch

The assessment was made on the basis of survey data obtained from 42 firms representing 10 factory types. The assessment was made difficult due to a lack of data or records being kept by factory managers. The information supplied by the respondents is mostly based on guesswork or rough estimates. This issue raises a major concern with regard to the reliability of the results. However, the overall aim of the assessment was to identify the material inputs versus outputs, review the machinery/technology utilised and identify significant waste generation practices. Some site observations were made when this was suitable but no pictures were taken due the fact that most mangers of firms were reluctant to give permission for this. The aims of the assessment were not satisfactorily met because of inadequate data.

4.1.1 Current waste minimisation assessment and site observation

For the purpose of assessing waste minimisation, respondents were asked what product(s) were manufactured/processed/packaged/assembled/repaired on-site. They were also asked what raw or other materials were used as inputs in the production process and what the respective quantities or volumes that were used each year were.

The aim was also to get information on the outputs/waste from all factories, but due to lack of or insufficient data this could not be achieved. The idea was to compare the inputs with the outputs in each type of factory but this was also impossible. Table 7 therefore

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summarises only the inputs and forms the basis of discussion in this subsection. Again, it has been impossible to make comparisons between different product usages by different types of factories. This is due to two main reasons, namely lack of data and size or scale of operations.

The principal inputs (with quantities) that were used in each type of factory are given in Table 7. It can be seen that for the dairy products factory (SIC 302) milk was the main input and 25 megalitres were used annually. Food manufacturers (SIC 304) used fruit (40 000 tonnes/annum) water, oil and spices. The principal inputs used by the beverage plant (SIC 305) were grapes (32 000 tonnes/annum) and bulk wine (250 000 000 litres per annum). Wine spirit was also used, but only 2,5 000 000 litres per annum. The textiles factory (SIC 311) reported fabric and boxes but the respondent could not estimate the quantities used. The footwear factory (SIC 317) used leather as the main input and 34 837m^2 of leather were used annually to make the products. The main products used in factories of type SIC 322 were wood, chipboard and U-F resin. However, it is not clear how much wood was used in total as different companies gave figures in different measurements.

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Table 7. Summary of input materials with quantities per annum, Stellenbosch 1999

Factory Type (SIC)	**Material inputs (principal)**	**Quantity used per annum (tonnes unless specified otherwise)**
302 Dairy products	Milk	25 megalitres
304 Food products	Water	300
	Oil	200
	Spices	300
	Fruit	40 000
305 Beverages	Grapes	32 000
	Bulk wine	250 000 000 litres
	Wine spirits	2,5 000 000 litres
311 Textiles	Fabric	unknown
	Boxes	unknown
317 Footwear	Leather	34 837m^2
322 Wood, cork & plaiting material	Wood	400
	Chipboard	100 sheets
	U-F Resin	4
342 Non-metallic mineral products	PVC	1 250
	Plasticisers	1 120
	Fillers	120
	Plastic	37
355 Fabricated metal products, metalwork service	Stainless steel	22
	ICs	unknown
	PCBs	30
	Cast iron	40
	Mild steel	unknown
	Aluminium	unknown
626 Maintenance & repair of motor vehicles	Nuts	200 kg
	Bolts	200 kg
	Brake shoes & pads	unknown
	Brake kits	unknown

Source: Industrial survey, 1999

It can also be seen that the non-metallic product manufacturers (SIC 342) used PVC (1 250 tonnes/ annum) and plasticisers (1 120 tonnes/annum) as main inputs. The main inputs for metal product manufacturers (SIC 355) were cast iron (40 tonnes/annum), PCBs (30 tonnes/annum) and stainless steel (22 tonnes/annum). Mild steel and

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aluminium were also used, although no estimates of quantities were provided. The motor vehicle maintenance and repair business (SIC 626) used mainly nuts, bolts, brake shoes and brake kits. However, the quantities given are only for bolts and nuts and they amounted to 200 kg each per annum.

All the above figures are rough estimates of quantities or volumes of input products used yearly by the different types of factory. With insufficient data or records it is not easy for the individual factories to determine how efficient their machinery is. There might be a considerable degree of damage to the environment due to inefficiency of the equipment used. It is important for the factories to keep proper records of materials used, products manufactured and waste produced. This could save the companies considerable amounts of money which could have otherwise been lost as waste material.

4.2 Potential waste minimisation measures

The potential for waste minimisation was determined by asking the respondents whether their respective factories had future plans for improving WM. The results are summarised in Table 8. The respondents were also asked which method they would prefer for collecting their recyclables if they were to implement the WM plan. These results are summarised in Table 9. Finally, the respondents were asked whether they were aware of any legislation pertaining to WM. Legislation could be used to promote WM where factories are not willing to implement the WM strategy voluntarily.

Table 8. Factories with plans for improving waste minimisation, Stellenbosch 1999

Intentions	No. of cases	Percentage
Yes	10	24
No	32	76

Source: Industrial survey, 1999

In Table 8 it can be seen that 10 of the 42 respondents were willing to improve, or had future plans to implement, WM measures in their factories. The willingness is low as only one quarter of the factories were willing to implement WM voluntarily. The factories which had plans to implement WM are those which produce large volumes of

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waste. They include the dairy (SIC 302), beverages (SIC 305) and wood, cork & plaiting material (SIC 322). These were the industries which were internationally and nationally recognised for exporting their products and probably are under pressure to practise cleaner technology in order to overcome competition and to comply with the ISO standards. Another possible reason is the fact that because these factories produce large quantities of waste, it would be more costly for them to dump the waste in landfills. About a quarter of the respondents said that they needed improved machinery in order to implement WM. One of the respondents mentioned that it would be economically viable and prudent to practise WM since input materials were getting more and more expensive. Most (70%) of the respondents believed that a continuous process of improvement of waste minimisation measures would be necessary in order to achieve desired levels.

The majority (76%) of the respondents said that their factories had no plans to implement WM. These are mostly small- to medium-sized industries which do not really experience any external pressure from either their competitors or clients to practise environmentally sound technologies. Respondents from some (8 out of 42) factories mentioned that they were investigating the possibilities for WM to be implemented in the future, while two factories had already implemented WM some years back.

The factories with no intentions of practising WM are those where the products are made on-site, while they are engaged in purchasing ready-made products and selling them, e.g. motor vehicle repair industries. None of the respondents actually mentioned the reason for not being willing to implement WM. This may be an indication that there is little awareness of the importance of environmentally-sound practices.

The respondents were asked which type of collector they would prefer to deal with if their recyclables were to be collected from their site (see Table 9). Only 36 (67%) of the 42 firms responded to this question. Fourteen of the 36 (39%) respondents declared that they would prefer the recyclables to be collected by private contractors. The main reason for preferring private contractors is that they are more reliable, since they are business-orientated and hence are more efficient. The second highest preference was given to the

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"other" option which, in most cases, referred to factories recycling on their own or selling the recyclable material. Again, this preference is money-orientated because of the belief that this can generate some extra income or save expenses with regard to recycling.

Table 9. Preferred method of collecting recyclables in Stellenbosch, 1999

Collector	No. of cases	Percentage
Municipality	7	19
Private contractors	14	39
Individual waste pickers	6	17
Other	9	25
Total	36	100

Source: Industrial survey, 1999

Interestingly, only seven of the 36 respondents (19%) prefer to use the services of the municipality for the collection of recyclables. This low figure is not surprising as most of the respondents believe that the municipality is not very efficient in collection of industrial waste. Local government was not seen to have the incentive to provide a good service for collecting recyclable industrial solid waste. The respondents who prefer the municipality to collect the recyclables do so because it is less costly to use the services of the municipality. Only six of the 36 respondents said that they would prefer their recyclables to be collected by individual waste pickers. At these factories respondents believe that the recyclables would not make much of a contribution to the factories' core business and they believe that giving the recyclables to the individual waste pickers can be regarded as job creation.

The respondents were also asked whether they were aware of any legislation or regulations pertaining to industrial solid waste minimisation that was currently (1999) on the statute books. Figure 17 diagrams the results. Seventy-nine per cent of the respondents were not aware of such legislation or regulations, and only 21 per cent were aware of such legislation. These figures clearly emphasise the need for an awareness or education campaign by the responsible government agency. They also suggest that there is a need for legislation enforcement to be strengthened and a need for regular checking

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or auditing to see where factories comply with the legislation or have an environmental management system in place.

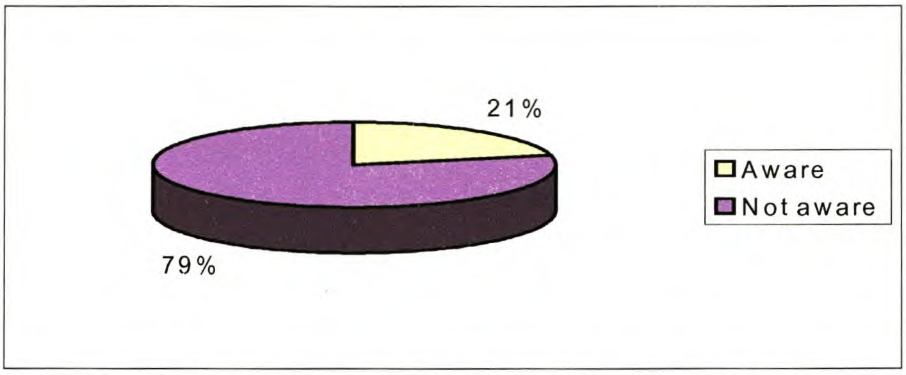

Figure 17. Factories' awareness of legislation pertaining to waste minimisation in Stellenbosch, 1999

The respondents were also asked whether they had any suggestions for improvement to industrial solid waste minimisation legislation or regulations. None to the respondents made any suggestions.

From the results given in Tables 8 and 9 as well portrayed in Figure 17, it can be deduced that the potential for WM is quite low if the factories were to be expected to practice a sound WM programme voluntarily without any external intervention. At the time of the survey only one in four respondents indicated that they had plans to improve or implement WM. Also, about 40 per cent of the respondent factories preferred the recyclables to be dealt with or collected by private companies. This is an indication that, if an initiative were to be made for the collection of recyclables from the factories, it would be better dealt with by private companies, since most factories have more confidence in them. If legislation is to be used as a tool to promote WM, it is clear (from Figure 17) that there is a need for a legislation awareness programme specifically targeting managers of firms. This should then be followed up with a strong enforcement campaign. The above-mentioned results indicate that there is a low potential of WM unless a sound regional strategy targeting all small- and medium-sized factories is developed and implemented by the responsible authority. The results of the study show

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that the smaller firms are still lagging behind in terms implementing industrial solid waste minimisation. Hence, it is important to investigate the industries' perceptions of WM before such a strategy is developed.

4.3 Industry perceptions of waste minimisation

The respondents were asked whether, in their opinion, the minimisation of industrial solid waste should be compulsory or voluntary. They were also asked to explain whatever reply they had given. The results are summarised in Table 10. The respondents were also asked if they would be willing to participate voluntarily if a WM programme were to be implemented in Stellenbosch and these results are also illustrated in Figure 18. Determination of these attitudes was necessary, as it would guide the development of a WM programme in Stellenbosch.

Table 10. Factory respondents' perceptions on waste minimisation, Stellenbosch 1999

Option	No. of cases	Percentage
Compulsory	20	48
Voluntary	16	38
No response	6	14
Total	42	100

Source: Industrial survey, 1999

About half of the respondents feel that waste minimisation should be compulsory. This is an indication that, should the local government implement a WM programme, there will be support from at least one out every two of the factories in Stellenbosch. The 38 per cent in favour of the idea of WM being voluntary is a positive sign showing that they do not object outright to WM; they just feel it should be non-compulsory. This is the constituency which could easily be convinced by a strong environmental education campaign. Six respondents did not answer this question. This can be seen as a minority group which could be forced to change their attitudes through strong enforcement of the legislation. This group would probably join the WM initiative if their neighbours engaged in it. A further awareness and education campaign would also help to influence the attitudes held by these particular businesses or individuals. This group has also been

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identified as sole owners of the factories in most cases. They probably feel that there are more important or urgent aspects of their businesses that they need to deal with.

When asked to give reasons why they said WM should be compulsory or voluntary, a range of answers were forthcoming. Consider the following selection:

- "Stellenbosch has more than enough by-laws."
- "Perhaps factories creating large amounts should be legislated."
- "A big % of waste can be re-cycled putting less pressure on the original source. Recycling means a cleaner country."
- "Due to the fast expansion of the industrial area in Stellenbosch every company needs to have a plan to save the natural environment from pollution."
- "In some instances it is not possible to do so e.g. it could mean lost production to some factories."
- "South Africa is not high on the list of international competitiveness mainly as a result of past political practices and the general level of education and therefore we do not have the 'economic platform' from which environmental management (in whatever form) could be enforced without a lot of business[es] going under (and the subsequent loss of jobs)."
- "Costly infrastructures required by authorities – burden on taxpayer and strain on the environment as industrialisation expands."
- "Solid waste control should depend on the manufacturing sector to be controlled as it is a concern for the future."
- "To save the planet."
- "If it is voluntary nobody will do it."
- "It will bring the overall amount of money spent on waste disposal down (money which comes from taxpayers)."
- "I think for any business it is important to try and save money where you can. Giving in old scrap metal and selling old oil is a way of getting money in but also keeping our country clean."
- "Could keep littering areas under control."
- "It will ensure that all industries will minimise waste."

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- "If you haven't got [it] in yourself to clean, conserve and to respect yourself and God's nature, no laws would do that."
- "Should be cost-driven."
- "In my opinion you cannot force anybody to do recycling at his firm."
- "Depending on [the] kind of waste [whether] it [is] solids or liquids. If applicable, minimisation should be compulsory to compensate for ozone [depletion] and general environmental health."

A number of observations can be made about these comments. One is that there is a good number of respondents who can actually connect waste generation with the environmental consequences and the economic effects thereof. The majority of the respondents who made comments seem to have a good understanding of this. However, a few respondents who do not seem to understand this fully, are unaware of environmental degradation caused by waste generation. On the other hand there are respondents who think that the larger factories are the only ones causing damage, whereas their own factories, which produce significantly less waste, have no problem. The fact of the matter is that waste is waste, no matter how much it is, and space is needed to dispose of it. This is also an indication that an awareness and education campaign is necessary. Generally, there is good support for WM by the industries and this is promising because it will make the job easier when implementation of a WM strategy is attempted.

The respondents were further asked whether they would participate if a voluntary WM programme were to be introduced in Stellenbosch. They were required to give reasons for not wanting to participate in such a programme. Figure 18 shows that 71 per cent of the respondents were willing to participate voluntarily should a WM programme be introduced. This high degree of positive response is not surprising considering that 86 per cent of the respondents also indicated support for WM, either compulsorily or voluntarily (see Table 10).

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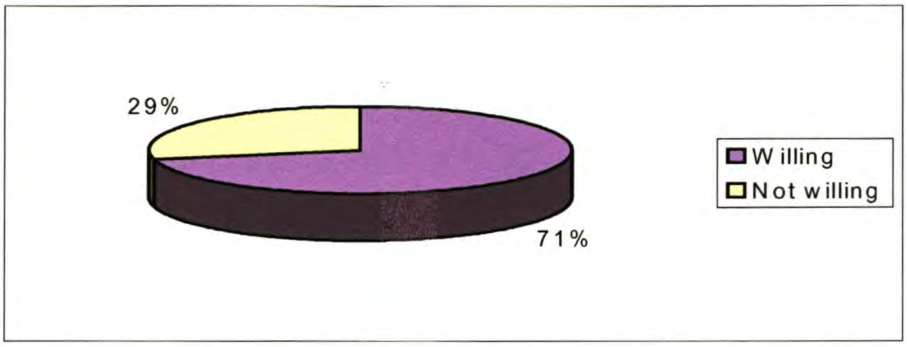

Figure 18. Willingness to participate in a voluntary waste minimisation Programme in Stellenbosch, 1999

These survey results are encouraging, as it seems that most respondents are willing to participate in and understand the importance of participating in WM. The other 29 per cent who recorded unwillingness to participate in a voluntary WM programme might be from the 14 per cent (Table 10) who did not respond to the question about whether WM should be voluntary. Again, this does not come as a surprise as one cannot expect to get 100 per cent acceptance of a new concept or buying into a new practice. Some people are too conservative to change easily and need to be convinced that the concept will bring positive spin-offs, either to the particular individual or the environment, or both. One of the reasons given for not being interested was that it was "time consuming". This is an indication that some of the respondents do not have a clear idea of what WM is about. The group that does not support participation probably needs an education and awareness programme to be convinced. Enforcement by legislation should be seen as a last resort.

4.4 Constraints on waste minimisation in Stellenbosch

The main constraint on WM in Stellenbosch and South Africa is the fact that it is a relatively new concept which requires expertise to be implemented properly. This would include the government authorities, the management of firms, and employees. The main problem is that most respondents still see WM as recycling only and not as reduction of waste during all phases of production, namely from the extraction of raw materials, through the production, transportation and disposal phases. It is evident from the survey

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that there is a problem in terms of awareness of the WM concept, as most respondents referred to recycling as if it was the only WM measure. Since this is a relatively new concept there is little expertise in the field of waste management for implementing a sound WM strategy. This expertise is lacking on the side of both the government and the factories. Again, there is a lack of awareness in terms of the environmental consequences, economic consequences and legislation pertaining to WM.

There is also a problem of attitude as some respondents (40%) say that the amount of waste produced by their factories is insignificant compared to other factories. The fact of the matter is that, no matter how much waste one produces, that waste material is a by-product of a raw material and eventually it needs to be disposed of, meaning that space is needed for the disposal of this waste. There is also a problem of unwillingness to share information by those companies who already have a WM plan in place. One of the reasons probably stems from competition in terms of the selling of products. There is a reluctance to give all information as some of the factories are afraid that the companies' secrets of success will be revealed to their opponents. Since there is lack of awareness among all parties concerned, including the clients, the factories are not forced to practise sound environmental practices, which would include WM. In most developed countries, the clients are environmentally aware and this forces the factories to implement environmental management systems, which, again, would include WM. Since most of the surveyed factories did not have an environmental management policy in place, they did not have sufficient records of their inputs and the waste generated. If there is no data (records) it would not be easy to do an environmental audit which would reflect the status of the WM and would also help to identify how to improve the existing situation. One of the constraints seems to be lack of financial resources, since the implementation of a sound WM would require an initial cash injection to allow it to be implemented. In some instances there would be a need to change existing equipment that is old and no longer efficient and hence produces more waste. Finance would be required to purchase such equipment. Finances would also be required for training all personnel involved with WM and this would include the managers and employees of the firms. The national, provincial

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and local authorities would also need to train and equip enforcement personnel, which would also require extra funds.

All in all, at the time of the survey there seemed to be a lack of incentives for the factories to implement WM, hence most of them did not bother to take any initiatives to implement WM. None of the parties concerned were doing anything to practise WM and this includes the government at all levels, the factories and the public.

4.5 Suitability of the waste minimisation assessment methodology

The questionnaire (Addendum B) was used as the only tool for assessing waste minimisation in Stellenbosch. In this case the questionnaire offered an opportunity to the respondents to provide information on the input (materials) and output (waste) of the factories. Due to a number of reasons, the methodology was not really suitable. The main reason is that in many cases no records of materials utilised and waste produced were kept. Consequently the efficiency of the machinery used and the measures in place could not be evaluated. However, other aspects of WM, like the firm's intentions and current practices, could be determined by using the questionnaire.

Recall Figure 7 (Section 2.3) in which the main steps of the assessment phase are shown, namely

- data collection;
- organisation of data;
- identification of significant waste generation practices; and
- site review.

The first and most important step, data collection, presents the main problem since most factories do not keep records. Only a few factories, mainly the well-established ones, kept records. Even though they kept records, they were not consistent in terms of timing and type of data recorded. This made it difficult to apply the WM methodology. The second step of the WM methodology concerns the organisation of data. This step is dependent on

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the first step. If the data or records are not kept, there is nothing to organise. As it is very important that data is recorded consistently in terms of presentation and timing, it has not been possible to comprehensively assess the WM in Stellenbosch even for those factories that keep records. This means that their data could not be organised since records were not kept and this was the case for those factories that had recorded some data. Some factories have never recorded the data at all, although it is possible that some had data but were hiding it due to a number of reasons. The third step, which is the identification of significant waste generation practices, was done by means of section B in the questionnaire. Most respondents did complete this section. This was suitable and the results have been discussed in section 3.1. Chapter 3 also included a focus on WM practices employed at the time of the survey, as well as the potential for WM. The fourth task of the methodology, site observation, could not be fulfilled either. Most of the factories were reluctant to allow someone from outside the organisation to do a site observation. A few factories allowed site inspection, but refused visual recording of findings. The equipment, input materials and waste material produced were inspected to get a better understanding of how the system functions.

One of the main problems concerning the applicability of the WM assessment methodology is the fact that many different types of factories were assessed at the same time. Even though the factories were aggregated into ten categories (see section 3.1) it was still not possible to make direct comparison of information gathered from different factories as they all have different practices or styles of management and means of handling data.

In section 2.3 it was recorded that a successful WM programme requires management to have measurable goals and time frames which can provide a basis for measuring. Examples of such include:

- Reduce emissions and wastes of a plant by certain percentages in a specific time.
- Set targets for waste reduction and emissions per annum. The goals should be flexible and adaptable to account for conditions encountered in actual practice.

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- Define terms in such a way that they are understandable to the management for implementation. The goals should be challenging enough to motivate the staff (Crittenden & Kolaczkowski, 1995).

In the case of Stellenbosch, most of the firms did not have any environmental management policy, let alone quantitative goals and time scales which could be used as benchmarks. This means that the concept of benchmarking was going to make it difficult to apply the WM assessment methodology. For the WM methodology to be applied there is a need for a standardised format for compiling and reporting information. The absence of this seems to be the main problem hampering this case study.

After an assessment of the WM status quo above, it is necessary to review the WM in Stellenbosch before recommendations for a regional waste management strategy are made in the next chapter.

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5. SYNTHESIS

The final chapter reflects on waste minimisation in Stellenbosch and makes recommendations about the way forward. This chapter aims to review WM by summarising the previous chapters. Following this, recommendations for regional WM will be made. Suggestions for further research are given.

5.1 Review of waste minimisation in Stellenbosch

This review is based on the waste assessment methodology and the main source of information was the questionnaire (see Addendum A). The questionnaire was designed to assess WM practices in Stellenbosch and their efficiencies or limitations. Some comments or suggestions made by the respondents as to how WM should be implemented will also be looked into. The practices are reviewed according to the WM methods listed in Figure 6 and section 2.2. The WM methods which were stipulated in the literature will be used as a guideline for this review of industrial WM in Stellenbosch.

Product changes: As mentioned in section 2.2, "product changes are reformulations of final or intermediate products, performed by the manufacturer, in order to reduce the quantity of waste arising from its manufacture" (Jackson, 1991; Johannson, 1992). When taking a closer look at the WM practices in Stellenbosch, set out in Table 5, the product changes referred to as material-related change method was currently practiced by five (23.5% of factories) of the ten factory types (i.e. SIC 302, 304, 322, 325 and 355). This method was started by one of the factories in 1994 and the maximum weight bulk reduction is 60 per cent.

Input material changes: "Changes in input materials may also lead to a reduction in, or avoidance of, the formation of wastes" (Crittenden & Kolaczkowski, 1995; South Africa, 1994). This method is referred to as material-related change (MRC) in Table 5. This method, like the product change method, was practised by five (23.5% of all factories) of the ten factory types at the time, and it was also implemented in 1994 for the first time.

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Technology changes: According to the literature "technological changes concern process and equipment modifications in order to reduce waste, primarily within the production environment" (Johannson, 1992). This method is the most uncommon method amongst the source reduction methods listed in Table 5 (ERC). Only two factory types out of the ten practiced this method and only seven per cent of the factories.

Good practice: As stated in the literature "attention to good operating practice, good housekeeping, good engineering and maintenance which involves operational improvements or administrative changes can often be implemented relatively quickly to reduce waste" (Crittenden & Kolaczkowski, 1995). This method has been referred to in Table 5 of subsection 3.2.1 as personnel related change and was practiced by 28.5 per cent (12 of the 42 factories) of the factories. However there might be more factories practising this method but this could not be determined due to poor record keeping.

On-site recycling: It is said that the "optimum place to recover wastes is within the production facility". Five of the ten factory types (but only 29% of the factories) practiced recycling on-site by using materials for low-quality purposes (see Table 6). It can also be deduced that large volumes of waste can be minimised by recycling on-site as presented in Table 5.

Off-site recycling: According to the literature "wastes may be considered for use or reclamation off-site when: equipment is not available on-site to do the job; not enough waste is generated to make on-site recycling cost-effective; and/or the recovered material cannot be used in the production process" (De Larderel, 1992). This method was the most widely used by 8 out of 10 types and 64 per cent of factories, as seen in Table 6. Some of the factory types in Stellenbosch sold the waste material that could still be used to other factories.

Reuse: "In an affluent, consumerist society many used products end up in the waste stream before they have ceased to function effectively" (De Larderel, 1992). This method is more or less related to recycling. Recycling and reuse are frequently confused. No

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factories indicated that they were reusing the waste, which might also reveal the issue of confusing reuse with recycling.

Reclamation: "Reclamation involves the processing of waste to recover valuable material or to make waste material suitable for subsequent reuse" (Taylor, 1993). This method is also not easy to distinguish from recycling, so the respondents sometimes might have referred to reclamation as recycling. Again, it could not be determined whether this method was being practised or not.

Energy recovery: The recovery of energy from waste is not restricted to incineration and can include the deliberate generation of methane in digesters. None of the respondents mentioned practising this method, but it is possible that some factories were practising this method at the time.

From the discussion above, it is clear that some WM was being practised at the time of the research even though it was not well co-ordinated in most cases. The most common method of WM was on-site and off-site recycling which involves selling of recyclables. This is mainly because there were no costs involved and no special knowledge was required for this method. The least common method was the equipment-related change, which might also be due to high costs which would be involved to change the equipment.

To summarise, WM assessment methodology would be more applicable if there had been good record-keeping of information related to inputs and waste material. There seemed to be lack of commitment to implement WM by the management of most of the factories. Another inhibiting factor is the fact that most factories were reluctant to release information. There was also a lack of understanding of the concept of WM on the part of the managements of many factories and probably among the staff members.

5.2 Recommendations for regional waste management strategy

In order to recommend a regional waste management strategy which would include WM, it was necessary to find out what the respondents thought would be the appropriate way

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to implement a WM plan. A selection of comments made by the respondents are listed below:

- "The important thing is for people to work together and in that way you can have success with waste minimisation."
- "Everything that can be recycled should be collected by such companies".
- "Separation of types of solid waste in different bags, e.g. paper and glass can enable easier recycling."
- "More recycling collection bins."
- "Recycling project should be sponsored by the Department of Environmental Affairs."
- "Tax rebate to industries reducing waste volumes leaving site."
- "Create work-groups; define the opportunities and challenges; define strategy with appropriate milestones."
- "Erect a big handling and recycling plant."
- "Selection and waste sorting facilities so that the types of waste can be separated".
- "Each company must be responsible for its own action plan (in conjunction with the municipality) to control solid waste."
- "A general point where waste can be delivered."

These comments reveal that there is a need for all stakeholders involved to work together and there is also a need of government intervention at all spheres from national to local government. The recommendations for a regional waste management strategy are summarised in the following subsections.

5.2.1 Legislation and regulations

According to Harries (1993) waste minimisation is not only a prudent step for industries to take, but is also an integral part of environmental regulations in many countries. He says that current waste management programmes therefore tend to emphasise waste minimisation, recovery and reuse to the maximum extent feasible. In the development of a regional waste management strategy, the legislation and regulations can be used as a

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tool for implementation. A national government department should develop legislation that will force industries of all sizes to implement waste minimisation as part of the overall waste management plan. The local government of Stellenbosch can also introduce by-laws which would compel factories to reduce waste as much as they can. They could also increase the levies for waste disposal and in this way factories will have to develop means to minimise waste at source. If such legislation is developed, the government (local) will have to establish the necessary infrastructure in order to enforce the legislation. It will also be necessary to establish a unit that will be responsible for enforcing this legislation within the waste management division. This means that there will be need to acquire funds, increase human capacity and train employees.

5.2.2 Education and awareness campaign

Once local government has the necessary infrastructure and has trained employees in waste minimisation, the personnel should go out and educate the public and the management of firms about the importance of WM and legislation pertaining to it. This could be done by hosting regional workshops to which all the managers of firms would be invited. The general public should also be made aware of the environmental consequences when factories do not use clean technology. Factories could be required to make their environmental policy available to the public on request. In this way the public would be able to apply pressure by a boycott of those factories that do not have environmental policies.

5.2.3 Training and capacity building

Once the industries' managements have been to workshops offered by government officials, they could receive further training on all aspects of waste minimisation, including good practice (good operating practice, good housekeeping, good engineering and maintenance) which involves operational improvements, or be helped to apply administrative changes which can often be implemented relatively quickly, to reduce waste. Emphasis should also be put on record keeping and data organisation, which would help when conducting a WM assessment. The general staff should also be capacitated to handling products during the production stage to minimise waste and with

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regard to environmental issues, including the factories' environmental management policy.

5.2.4 Establishment of working groups

The local government should take the initiative and establish a working group which would see to the overall implementation of a WM strategy. The group should meet on a regular basis to identify all needs for the implementation of the strategy and also to assess how continuous improvement could be established. The group should be as representative as possible: it should include government officials, representations from the factories and from the general public. Experts in the field of WM should also be on the working group so that they can give advice. The group should include personnel who are capable in the following fields of expertise: design and process engineering; environmental issues; production and maintenance; legal matters; accounting; finance and purchasing; health and safety; research and development; operators, supervisors, transport; and external consultants. The responsibilities of the group should also include investigating means of getting funding for pushing the programme forward.

5.2.5 Implementation by factories

The factories should develop an environmental management policy which outlines how waste minimisation will be carried out. The first step would be to do a WM assessment in the factories to identify needs. The following elements should form the basis of WM assessment:

Programme initiation;
Data collection and audit preparation;
Waste audit;
Identification and prioritisation of WM alternatives;
Feasibility analysis;
Waste assessment report; and
Monitoring, feedback and re-evaluation (Crittenden & Kolaczkowski, 1995).

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Programme initiation

It is important to get full support and commitment from senior management and it is important to appoint a programme leader who will be responsible for driving the project forward. The leader should see to it that the company's policy statement is issued and that there is dissemination of information to all staff to raise awareness. It is also important that the goals and time frames are set. The goals should be achievable and can be quantified.

Data collection and audit preparation

After the programme is launched, the second step would be to get together an audit team. The team leader should co-ordinate this team. It will be necessary for the team to have the necessary expertise regarding industrial operations, waste and environmental regulations, and waste minimisation alternatives. It is also advisable that at least one external person with WM experience be included in the team. They should access, assemble and review site information so that they can obtain an idea of what is involved in the firm.

Waste audit

This phase involves going into the plant to confirm information, collect additional data and develop a detailed and practical understanding of how and where the waste streams are generated. This is carried out in four major steps, namely

- Site investigation;
- Construction of process flow diagrams;
- Definition of process inputs and outputs; and
- Material balance.

Identification and prioritisation of WM alternatives

The waste minimisation alternatives are to be identified from the information collected in the audit phase. The team should then evaluate and screen the WM alternatives that have been identified. The alternatives should be prioritised, starting with source reduction.

Feasibility analysis

The WM alternatives taken to the feasibility analysis stage will depend on the time and resources available for the programme. The alternatives should be evaluated in terms of

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technical and economic feasibility. The economic evaluation of WM alternatives should be carried out with regard to the company's preferred methods.

Waste assessment report

Upon completion of the assessment, it will be advisable to document all the information and findings of the study in a report.

Monitoring, feedback and re-evaluation

After issuing of the report it will be necessary to institute a continuous assessment programme in order to assess success. Feedback should be given to all staff members and the assessment team in order to create some interest in the initiative. There should also be a continuous re-evaluation programme in order to check whether there is room for improvement.

The above-mentioned regional waste management strategy as per the literature and the study findings will require commitment from all parties involved–from the government, the factories, and the public. It should be emphasised that implementation of this strategy will take a long time since this is a process, not an event.

5.3 Recommendations for further research

This study included all the factory types in Stellenbosch. The sampling methodology used has both positive and negative consequences for the findings of this study. The positive side of it is that an idea was obtained about the state of WM generally within the Stellenbosch firms which is important because no such study has been conducted in Stellenbosch before. Now the current state or level of implementation of WM has been determined. But the study does not really get to the finer details with regards the WM situation; it only gives an overview of the issues pertaining to WM in Stellenbosch. Given the limited time and resources available for the study much ground work has been covered. However, there is room to investigate the situation at depth, hence the following recommendations for further research:

a) A case study focussing on SMMEs since they have been identified in the current study to be lagging behind.

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b) A case study focussing on large-scale industries to come up with further suggestions to improve the situation pertaining to this category.
c) A case study focussing on one of the ten SIC factory types in one industrial area.
d) Another possibility would be to focus only one factory in each of the ten SIC categories listed in Table 1 and do a comparative study.

There is a need for further research if there are intentions to develop policy for industrial WM or development of a WM strategy in WM in Stellenbosch and this could be expanded to other parts of South Africa. All stakeholders will benefit and the environment which is under pressure of degradation will be sustained by implementing the findings of the study and using the findings to inform strategy, policy and legislation development.

Words 18 620

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LIST OF REFERENCES

Allaby, M 1990. *The green house effect and other key issues*. London: Hamlyn.

Ball, C 1999. *The sustainable management of solid waste.* New York: The Local Government Management Board.

Bethlehem, L & Goldblatt, M, 1999. *The bottom line: Industry and the environment in South Africa*. South Africa: Industrial Strategy Project

Clark, JH 1995. *Chemistry of waste minimisation*. London: Blackie Academic & Professional.

Coleman, AE 1994. An assessment of the potential for waste minimisation in small and medium size enterprises in South Africa. MSc Dissertation. Cape Town: University of Cape Town.

Crittenden, B & Kolaczkowski, S 1995. *Waste minimisation: A practical guide*. Rugby: Institute of Chemical Engineers.

De Larderel, J 1992. *The institute of solid waste year book 1991-1992.* New York: Wiley

De Necker, PH 1987. Industrial linkages in Greater Cape Town: Spatial patterns of purchases and sales. PhD dissertation. Stellenbosch: University of Stellenbosch.

Environmental Monitoring Group, 1993. *Clean Production: A preliminary assessment of need and potential for the introduction of clean technology in some industrial sectors in South Africa.* The Environmental Monitoring Group: Western Cape

Erwin, L & Healy Jr, LH 1990. *Packaging and solid waste management strategies.* New York: AMA Membership Publications Division.

Fairest Cape Association 1998. *Waste minimisation*. Cape Town: Fairest Cape Association.

Harries, RC 1993. Waste auditing and minimisation – practical procedures and case studies. *In Effluent treatment and waste minimisation.* Edyvean, RG, Bailey, DA Boutwood, PJ, Handley, D, McGreavy, C, Pitt, M, Short, & C, Stentiford, E (eds.). ICHEME Symposium series no. 132: 41. Rugby: Institute of Chemical Engineers.

Jackson, FR 1991. *Recycling and reclaiming of municipal solid wastes.* London: Noyes Data Corporation.

Stellenbosch University http://scholar.sun.ac.za

Johannson, A 1992. *Clean technology*. Lewis Publication 1992. South Africa. Western Cape Recycling Forum, Fairest Cape Association.

Porteous, A 1991. *Dictionary of environmental science and technology.* Philadelphia: Open University Press.

Rossiter AP & Kumana J, 1995. *Waste minimisation through process design*. New York: Mc Graw Hill, Inc.

Semoli BP, 1999. *Literature review on industrial waste minimisation*. Stellenbosch.

Shand, N 1993. *Guidelines for waste management in South Africa.* Cape Town: Ninham Shand (Inc).

South Africa, 1983. *The Factory Act No. 3 of 1983. Statutes of the Republic of South Africa.* Pretoria: Government Printer.

South Africa, 1993. *The Factory Act No. 137 of 1993. Statutes of the Republic of South Africa.* Pretoria: Government Printer.

South Africa, 1994. *Minimum requirements for the handling and disposal of hazardous waste*. Pretoria: Department of Water Affairs and Forestry.

South Africa, 1996. *The Constitution of the Republic of South Africa, Act 108 of 1996.* Pretoria: Government Printer.

South Africa, 1998a. *National Environmental Management Act No. 108.* Pretoria: Department of Environmental Affairs and Tourism.

South Africa 1998b. *White paper on integrated pollution control and waste management.* Pretoria: Department of Environmental Affairs and Tourism.

South Africa, 1999a. *National waste management strategy.* Pretoria: Department of Environmental Affairs and Tourism.

South Africa, 1999b. *Waste planning AP.* Pretoria: Department of Environmental Affairs and Tourism.

Steyl, ID 1996. Solid waste in rural Stellenbosch: nature, extent and handling strategies. MA Thesis. Stellenbosch: University of Stellenbosch.

Sutter, H 1989. Low-waste technologies in the Federal Republic of Germany. *The Environmental Professional.* Vol. 11: 112-121.

Taylor, B (ed.) 1993. *Waste and recycling.* London: A & C Black Ltd.

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ADDENDUM: Questionnaire

Date: August 1999

QUESTIONNAIRE SCHEDULE ON INDUSTRIAL SOLID WASTE MINIMISATION IN STELLENBOSCH.

INTRODUCTION

Mr Belemane Semoli, a senior student in the Department of Geography and Environmental Studies at the University of Stellenbosch, is currently doing a survey on the minimisation of industrial solid waste in Stellenbosch. The idea is to establish what is presently being done, and what can be done in the future to reduce the growing volume of solid waste materials produced by factories and other industrial concerns in Stellenbosch. As you may know, waste minimisation is an important element in recent thinking on more efficient strategies for waste management; it not only helps to reduce handling costs and decrease the pollution hazard, but also extends the lifespan of landfill sites. In view of the foregoing it will therefore be greatly appreciated if you could assist Mr. Semoli by answering the following questions as fully and accurately as possible. Please be assured that your answers will be treated as completely confidential and that no individual firm will be identified in the final report.

Thank you for your willingness to participate in the survey.

Mr. MKR van Huyssteen
(Senior Lecturer)

INSTRUCTION: To be completed by or in the presence of the factory manager.

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SECTION A: GENERAL INFORMATION

1. Name of the firm? ……………………………………………………………………………

2. Respondent's position in the firm? …………………………………………………………

3. Address? (i) Street ……………………………………………………………………………
   (ii) Industrial area ………………………………………………………………………………

4. Total number of full-time employees? ……………………………………………………

5. What product(s) is/are manufactured/processed/packaged/assembled/repaired on this site, what raw or other materials are used as *inputs* in the production process, and what are the respective *quantities/volumes* of each per year?

Product(s)			Input(s)		
Type of product (e.g. wine, toys, etc.)	Volume/ quantity produced *per year*	Units (e.g. number, or litres, or tons, etc.)	Type of input (e.g. grapes, wood, PVC plastic, etc.)	Volume/ quantity used *per year*	Units (e.g. number, or litres, or tons, etc.)
(a)*Principal product(s)* (i) ……………… …………………… (ii) ……………… …………………… (iii)……………… ……………………	………… ………… ………… ………… ………… …………	………… ………… ………… ………… ………… …………	(a)*Principal input(s)* (i) ……………… …………………… (ii) ……………… …………………… (iii) ……………… ……………………	……… ……… ……… ……… ……… ………	………… ………… ………… ………… ………… …………
(b)*Secondary product(s)* (i) ……………… …………………… (ii) ……………… …………………… (iii)……………… ……………………	………… ………… ………… ………… ………… …………	………… ………… ………… ………… ………… …………	(d) *Secondary input(s)* (i) ……………… …………………… (ii) ……………… …………………… (iii)……………… ……………………	……… ……… ……… ……… ……… ………	………… ………… ………… ………… ………… …………

SECTION B: GENERATION AND COLLECTION OF SOLID WASTE

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1. Is most of the waste produced on-site solid, liquid, or of roughly equal amounts?

Mostly solid		More or less equal amounts		Mostly liquid	

3. What *specific* type(s) of solid waste (e.g. paper, plastic, metal, glass, etc) is produced on-site, in approximately what *quantities* (e.g. tons) *per month*, and what percentage of it is *done away with on-site* (e.g. through burning, burial, composting, reuse and/or recycling)?

Type(s) of solid waste	Quantity (tons) per month	% done away with on-site	Disposal method(s)	Frequency of disposal (e.g. once/ week)	Disposal cost per month (R)
(i)					
(ii)					
(iii)					
(iv)					
(v)					
(vi)					
TOTAL					

3. Who collects and removes the remaining waste, if any?

Self		Private contractor		Municipality		Other (specify)…………..	

4. If removed by your firm itself, what method is used and where is the waste disposed of, once off the premises?

i) Disposal method(s) (e.g. dumped, burned) ………….……………………………………

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ii) Where? (e.g. municipal dump-site) ....

5. Are there any environmental problems (e.g. bad odour, litter, water contamination, etc) caused by the waste while stored on the site prior to its removal? Yes ☐ No ☐

6. If Yes, please specify the type(s) of problem: ....
....

7. If you are aware of any problem(s) caused by solid waste while stored at any other factory/ies in Stellenbosch, please indicate the name(s) of the factory/ies and the type(s) of problem.

Name(s) of factory/ies	Type(s) of problem
(a)..................................	(i) .... (ii) .... (iii) ....
(b)	(i) .... (ii) .... (iii) ....
(c)	(i) .... (ii) .... (iii)..

SECTION C: PRACTICE AND POTENTIAL OF SOLID WASTE MINIMISATION

1. Are you familiar with the concept of "waste minimisation" as a contribution to the improved management of industrial solid waste? Yes ☐ No ☐

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2. How important do you regard the potential contribution of waste minimisation to improved industrial solid waste management?

highly important	1	2	3	4	5	not important

3. Which (if any) of the following solid waste minimisation options is / are currently practised by your firm?

Option		Year when started using	Is the minimisation done on-site or off-site?	% weight/bulk/ volume reduction achieved?
(i) *Source reduction* - equipment related change - personnel related change - material related change				 ....
(ii) *Recycling/re-use* - material(s) sold - material(s) used by firm for poorer quality purpose				 ....
(iii) *Other option(s)* (specify)....................				 ....

4. Does your firm have any plans to expand existing form(s) of waste minimisation or introduce new one(s) in future? (Please give details): ....
....

5. If your firm practices recycling at present by selling recyclables, or has plans to do so in future, who collects/would you like to collect your recyclables?

i) The municipality	
ii) Private contractors	
iii) Individual waste pickers	
iv) Other (specify)	

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6. If your firm does *not* currently practice any form of waste minimisation, nor has any such plans for the future, what is/are the reason(s)? ....
....
....

7. Are you aware of any form(s) of solid waste minimisation currently practised by other firms/factories in Stellenbosch? Yes ☐ No ☐

8. If Yes, please name the firm(s) as well as the type(s) of waste minimisation practised.

Firm(s)	Waste minimisation method(s) employed
(i)	
(ii)	
(iii)	
(iv)	

9. Are you aware of any legislation or regulation(s) pertaining to industrial solid waste minimisation that is/ are currently on the statute books? Yes ☐ No ☐

10. If Yes, do you have any suggestions for improvement(s) to such legislation or regulation(s)? Please specify:..
....
....

11. In your opinion, should the minimisation of solid industrial waste be a compulsory ☐ or a voluntary ☐ matter?

    Please explain your answer: ....
    ....
    ....
    ....
    ....

12. If a voluntary waste minimisation programme is introduced in Stellenbosch, would you participate? Yes ☐ No ☐

13. If No, please specify the reason(s): ....
    ....

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14. If Yes to Q. 12, what suggestion(s) do you have for such a voluntary solid waste minimisation strategy for Stellenbosch industries? …………………………………...
…………………………………………………………………………………………

15. Any additional remarks or suggestions with regard to the minimisation of industrial solid waste in Stellenbosch? …..…………………………………………………..
……..……………………………………………………………………………………..
…..………………………………………………………………………………………..

Thank you, for your participation!

The completed questionnaire will be collected five days after delivery.