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Composting of Municipal Waste in South Africa

sustainability aspects

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Abstract

Composting of Municipal Waste in South Africa - sustainability aspects

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South Africa is facing large challenges in developing waste management. The amount of waste is increasing as more people are leaving poverty, and the sustainability of disposing waste at landfill is both economically and environmentally questioned. This has resulted in a search for alternative treatment of waste and composting is one of the alternatives looked upon by many municipalities. It is thus important to evaluate sustainability aspects of already running composting projects treating municipal solid waste. The objective of this study was to do that by looking at the technological process function, environmental impact, economic sustainability and social policy fulfilment of seven case studies.

All of the projects succeeded in producing a marketable product. The measures taken to reduce negative environmental impact were in most cases kept at a minimum, as it was looked upon as a non-issue in composting of green waste. None of the projects did at the time generate enough income to cover the costs but some of the projects had good chances to break even, or be profitable, in a close future. A few projects were already considered economically sustainable when taking the savings from alternative treatment into account. Our study further suggests that the organisational form of co-ops were best at increasing the status.

This study has been conducted as a Minor Field Study with financial funding from the Swedish International Development Cooperation Agency (SIDA) and in collaboration with the Nelson Mandela Metropolitan Municipality in South Africa.

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Sammanfattning

Sydafrika, liksom många andra länder, står inför problemet med en växande mängd avfall som måste tas omhand. Tidigare har allt avfall lagts på soptippar vilka inte har uppfyllt tillräckliga miljömässiga standarder för att hindra skadlig miljöpåverkan. Ny lagstiftning har gjort att större krav ställs på soptipparna och flera har därmed fått läggas ned.

Även om de nya soptipparna bättre fyller kraven på skydd för läckage av miljöskadliga ämnen är denna typ av avfallsbehandling problematisk. Dels är det dyrt att bygga och sluttäcka deponier, dels medför även en korrekt konstruerad deponi skadlig miljöpåverkan på sikt. Det finns därför starka drivkrafter att minimera mängden avfall som läggs på deponi, både i Sydafrika och i Europa. En alternativ behandling som är miljömässigt bättre än deponering är kompostering av avfall. I flera kommuner i Sydafrika finns därför återvinning och kompostering inskrivet i avfallsplanen. Det är dock endast ett fåtal som har kommit igång med detta arbete.

Denna studie innehåller en utvärdering av fem kommuner som redan påbörjat kompostering av kommunalt avfall. Utifrån de fakta vi samlat in genom besök och intervjuer ger vi en beskrivning av varje kommun, samt diskuterar hur väl de komposteringsprojekt som idag finns uppfyller, för kommunen intressanta, hållbarhetsmål.

Syftet med studien är att underlätta för kommuner som planerar att starta komposteringsprojekt genom att ge dem en möjlighet att dra lärdom av andra projekt, både direkt genom vår rapport, men också indirekt i form av framtida kontaktytor. Projektet har finansierats av Sveriges organ för internationellt utvecklingssamarbete, SIDA, och utvecklats i nära samarbete med Nelson Mandela Metropolitan Municipality i Sydafrika.

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1 Introduction

This study was developed in close collaboration with staff from the Waste Management Division of Port Elizabeth, Nelson Mandela Metropolitan Municipality[1] (NMMM). Currently the municipality has problem with illegal dumping of waste and all waste that is collected is deposited at landfills, without sufficient control of hazardous and medical waste. During the last years the municipality has, as a step to develop the management of waste, increased the waste retrieval rate and closed down improperly constructed and ill situated landfill sites. These improvements have led to excessive use of the two remaining landfills[2]. To reach a sustainable situation, an Integrated Waste Management Plan with plans for recycling and alternative treatment of some of the waste has been developed, and is about to be implemented[3].

This strive, to find alternatives to landfills, occur in most of South Africa's municipalities. Beside the municipalities' own interests in reaching financial and environmental sustainability it is also due to the national vision of a plan for zero waste to landfill by 2022.[4] International experiences show that composting can be accomplished with robust and cost efficient technology[5], why this is an interesting option for many municipalities. The aim of this study was to help reduce the gap between policy and implementation by making the experiences from already running South African composting projects available for actors that are planning to start up new composting facilities.

1.1 Background Problem

In the past decade there has been a growing awareness of the importance of environmental issues in South Africa. With more people increasing their material standard of living, the environmental strain is likely to enlarge, both due to increased use of limited natural resources, and due to larger amounts of waste and pollution produced.[6] Getting a better understanding of the poverty-environment-growth nexus and a stronger linkage between development programmes and environmental conservation is considered one of the biggest challenges for South Africa today.[7]

In March 2000, The Department of Environmental Affairs and Tourism (DEAT) launched a White paper on Integrated Pollution and Waste Management for South Africa[8]. This document explicitly represents a paradigm shift in how the waste problems are addressed. It states that, instead of taking action after the waste is generated, efforts should focus on preventing pollution and minimize waste by institutional integration and involvement of the societal sectors.[9] A year later, in September 2001, the first National Waste Summit meeting was held in Pietersburg[10] with representatives from the government at national, provincial and local level, business community and civil

[1] Soon to be known as the Nelson Mandela Bay Municipality (NMBM)
[2] Eric Zinn, pers com. 2005-08
[3] NMMM (2005)
[4] DEAT (2006-05-19a)
[5] Diaz (2003)
[6] DEAT (2006-05-19b)
[7] UNDP (2006-03-10)
[8] DEAT (2000)
[9] DEAT (2006-05-19c)
[10] Now renamed Polokwane

society. The outcome of this meeting was the Polokwane declaration which, among other things, states a vision of zero waste by 2022.[11]
Policy formulation and outline of the work towards sustainable development is done on a national level, but the direct implementation and formulation of strategy plans lies within the areas of provincial and local authorities. As waste collection and treatment is the responsibility of the municipalities, it is their task to implement and enforce appropriate waste minimisation and recycling initiatives.[12] Composting is one way for the municipalities to recycle waste and thereby reduce the amount of waste going to landfill.

1.1.2 Environmental benefits of Composting

The most considerable environmental benefit of composting is that the amount of waste going to landfill is reduced, since landfills caus serious environmental impacts. Water forms leachate when percolating through the waste and becomes contaminated by substances originating in the waste. This leachate contains oxygen depleting substances[13], toxic organic substances and metals, and can pollute ground and surface water. Lining and covering the landfill can in a short perspective prevent this, but in the long run some leakage is inevitable.[14] Another environmental impact is gas emissions. When water enters the landfill, biological activity starts and landfill gas is formed, including hydrogen sulphide and methane, which is an aggressive greenhouse gas.[15]

Composting biologically degradable waste not only reduces the amount of waste put on landfill, but can also reduce the environmental impact of the remaining waste at the landfill, since putting less organic matter in the landfill will reduce methane production.[16] There are also suggestions that less organic material in the landfill will reduce the negative environmental impact of leachate.[17] Fires on landfills is another factor with large environmental impact. With less organic waste going to landfill, the risk of fire can be reduced.

Compost has the potential of being a fertilizer[18] and can thus be environmentally beneficial by substituting artificial fertilizers . To what degree the compost will enhance the nutrient status of the soil depends on both the waste that the compost is made from and the treatment technology. [19] Even if the compost is low in nutrients it can be valuable since application of compost, or any other form of humic material, effectively enhances soil structure, improves the water holding capacity and reduces the sensitivity to erosion.[20] Several tests also show that application of compost represses plant diseases in the field[21].

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[11] DEAT (2006-05-19a)
[12] DEAT (2006-05-19c)
[13] substances that use oxygen when degrading
[14] Strömberg (1995)
[15] The Swedish Environmental Protection Agency (1993)
[16] The Swedish Environmental Protection Agency (1993)
[17] This is because the biological activities in the landfill are creating conditions that in a short perspective enhance the mobility of toxic compounds and metals, creating a stronger leachate(Laine-Ylijoki et. al (2005)) for a longer period (Van der Slot et. al (2001))
[18] Montemurro et. al (2005)
[19] Gutser et. al.(2005) Grehan, Dodd and Dennison (1996)
[20] Manser & Keeling (1996) pp 287
[21] Ros et. al (2005) Garcia et. al. (2004)

Composting thus reduces the risks of environmental degradation, but can also have other positive side effects, including economizing with limited natural resources, higher environmental awareness among the population and closing the nutrient loop between urban and rural areas. Composting is therefore an interesting option for municipalities developing their waste management by minimising and recycling waste that today ends up on landfill.

1.2 Objectives

When initiating new composting projects, it is valuable to have other projects to learn from and benchmark with. At the time for this study there was a lack of documentation concerning composting initiatives in South Africa and therefore little foundation for exchange of knowledge and experiences between different projects.

The main objective of this study was to map some municipal initiatives in composting of solid waste and, based on these case studies, describe how the composting projects were fulfilling the goals of the municipalities. By doing so, we aim to reduce the gap between policy and implementation by establishing contacts and making the experiences from already running composting projects available for actors that are planning to further develop, or start up new, composting facilities in South Africa.

1.2.1 Operationalisation of Objectives

In order to evaluate the composting projects, we had to specify what we consider as important evaluation parameters. Different actors have different expectations and interests, and therefore different goals and criteria for success. In defining our evaluation parameters we applied what we saw as a “municipality approach”. This model is based on the argument that a democratic municipality represents the whole society and thus is concerned with finding a solution for all parties rather than a single actor. Therefore a municipality will have many different goals with their compost projects, both in the technical, environmental, economic and social area. In our model the four main goals that a municipality has when promoting sustainable composting projects are; to transform the waste (main objective) in a way that is environmentally, economically and socially sustainable (the three dimensions of Sustainable Development). The areas of concern, the municipal goals for each area and how we have operationalised them in our study, are shown in Table 1. Background theory on these areas and goals is elaborated in chapter 3.

Table 1 Model and operationalisation of goals with sustainable compost projects

Area	**Goals for Municipality**	**Operationalisation**
Technological Process	To transform waste to a useful end product	What technology is used to decompose the waste? What (technological) problems are encountered and how are they solved? What is the quality and use of the end product?
Environmental Impact[22]	To minimise and control negative environmental effects	Are measures taken to reduce emissions from the process to air, water and soil? Is it likely that the compost has substantial environmental impacts?
Economic Sustainability	To achieve economic sustainability	What are the major costs of starting up and running a compost facility? How is income generated? Is the project economically sustainable?
Social Policy Fulfilment	To contribute to social development	Has the operator a defined goal to contribute to the political goals of skill enhancing, poverty alleviation and Black Economic Empowerment[23]? How does the project contribute to the fulfilment of these goals?

1.3 Methods

Seven case studies where selected for this report. The evaluation of these projects were based on interviews, physical and chemical data measured by the operators, our own observations and a literature study. The interviews were semi-structured in order to capture the dividing factors between the projects but still make the findings comparable. Another reason for using semi-structured interviews was that the areas of evaluation were somewhat overlapping and some questions will be relevant to more than one area which calls for a broader onset.

The questions for the interviews were based on the four areas of evaluation described above; Technical process, Environmental impact, Economical sustainability and Social

[22] To do a investigation of the actual environmental impact from a process is very difficult and thus out of scope of this study. What we aim to do it to investigate the environmental awareness of the operator, and if the composting process is constructed in a way that makes it likely that the environmental impact is limited.

[23] These policies in South Africa are to be considered in all governmental projects.

Policy fulfilment. Apart from these, the area Organisational Factors was also investigated, that is how the municipality chose to organize the project. This was not an area of evaluation since it was not a goal in it self, but here we expected to find factors that affect the goal fulfilment in the other areas which justified it as part of the data collection. The topics and questions that the interviews were structured around can be found in Appendix 1.

The physical and chemical data available from most of the projects was limited. In the projects where such measurements have been collected and recorded there have however been no problems in receiving this type of information. By visiting the projects at site valuable information on management and composting process was obtained, such as observations and information on odour and working conditions.

The visits to the projects lasted from one-half to three days. In most projects our key interviewee has been in managerial position, not working directly on the composting site. Most of these persons accompanied us and showed us the compost site themselves, but in a few cases we were encouraged to stay on the site by ourselves and interview workers and managers working directly on the site.

We have got the impression of an over all openness and willingness to share experiences in the projects. Still there are factors that limit and affect our comprehension and collection of data. The most limiting factor is that the interviewed persons themselves do not know all about their own project. In many cases even basic things are not measured, as for example amounts of waste treated. Other circumstances that might affect the precision of our data are that the interviews often were conducted in field and in a language that is foreign to both us and most of the interviewees. Further, the short time (one-half to three days) spent at the sites limits the value of our observations. The visits took place during the hot season which also is the most active season for the projects. We are aware of these limitations and have taken them into account when drawing our conclusions.

1.3.1 Selection of Study Objects and Demarcations

Since there had been no former large-scale mapping of ongoing composting projects in South Africa there was no formal source of information to use when selecting objects for the study. We found the projects via the Internet combined with personal contacts in Sweden and South Africa.

The basic criteria when selecting study objects was that the projects should use an aerobic composting process to treat municipal solid waste. Thus companies or projects treating industrial wastes, sewage sludge, faeces and/or urine were therefore not included in the study. Our intention was to first make a mapping of composting projects and then select some case studies with location, type of organisation (public or private), scale and type of composting process as selection criteria. In reality, it was more difficult to get in contact with project managers than we expected since Webpages and municipal e-mail addresses and telephone numbers often were out of date. Thus all the projects we got in contact with, that fulfilled the criteria above, where selected. Apart from the seven case studies we visited three additional projects. These three projects were either at the starting face or not treating municipal waste and were therefore not included. These visits were however useful in order to get a wider perspective on different approaches and methods of composting. Some comments on observations from these visits that are relevant to the discussion have been included in this report.

1.3.3 Participants of the Study

Most of the projects we have contacted have been very helpful and willing to take part in the study. None of the participants wanted to be anonymous, but due to competition reasons, some of the participants have made clear that they do not want all of the given information to be explicitly released in connection with their own or the company's name in the report. Since the focus of this study is not the specific projects themselves but rather the overriding features this has not been a problem. In our effort to make sure that no classified information is being printed, the participants have received a copy of the layout of the chapters and information concerning their company. They have then been given one month to respond on the matter before the release of this report.

1.4 Disposition

The report is structured in a way that makes it possible to read selected parts, depending on interest and former knowledge. In Chapter two, background theory is given that can be especially valuable for readers with limited insight in composting or in the South African context. In Chapter three a description of the visited projects is given. The common and dividing factors found in these projects are discussed in chapter four, and based on these discussions we draw conclusions on factors that affect the goal fulfilment under each area of evaluation in chapter five. Chapters three and four can be read independently of each other.

2 Background Theory

As mentioned earlier this description of composting projects focuses on four main goals that a municipality has when promoting sustainable composting projects. The first goal; to transform waste, is the very essence of waste management and is thereby a key factor in any evaluation of composting projects. The three other goals; environmental, economic and social sustainability, constitute the three dimensions of sustainable development. In this chapter we will give background and theory on each of these four goals.

2.1 Technological Process

Composting is the biological process occurring when organic matter is aerobically[24] degraded and turned into humus by microorganisms and invertebrates. Degradation occurs naturally, but under controlled circumstances it can be accelerated and thereby used for treating waste. Here we will give a brief overview of the biological process, important parameters for process control, technologies used for composting and quality criteria for the end product. For further readings we recommend the fact sheets edited by Cornell Waste Management Institute at Cornell University in USA[25].

2.1.1 Biochemical Process of Composting

In the process of composting, microorganisms break down organic matter and produce carbon dioxide, water, heat and humus, the relatively stable end product. There is not only one type of microorganisms responsible for the decomposing process, but an ecosystem of different organisms. Since composting is an aerobic process, the microorganisms that require oxygen are dominant. There are always pockets in a compost heap where the oxygen is depleted, and thus there will be some anaerobic organisms as well. Bacteria, fungi and actinomycetes[26] account for most of the decomposition as well as the rise in temperature. These microorganisms are eaten by small animals, such as invertebrates[27] and worms. The activity of these animals has the advantage of mixing the material, breaking larger particles to smaller ones and transforming the material into more digestible forms for the microorganisms.[28] In Figure 1 the food web of a compost heap is shown.

[24] An aerobic process is dependent on oxygen, in contrast to the anaerobic process which occurs without oxygen

[25] Cornell Waste Management Institute (2006-06-19)

[26] Aomycetes is a group of microorganisms intermediate between bacteria and true fungi. These organisms are responsible for the earthy smell of compost

[27] An animal without a backbone or spinal column

[28] Ministry of Agriculture and Food Brittish Columbia (1996)

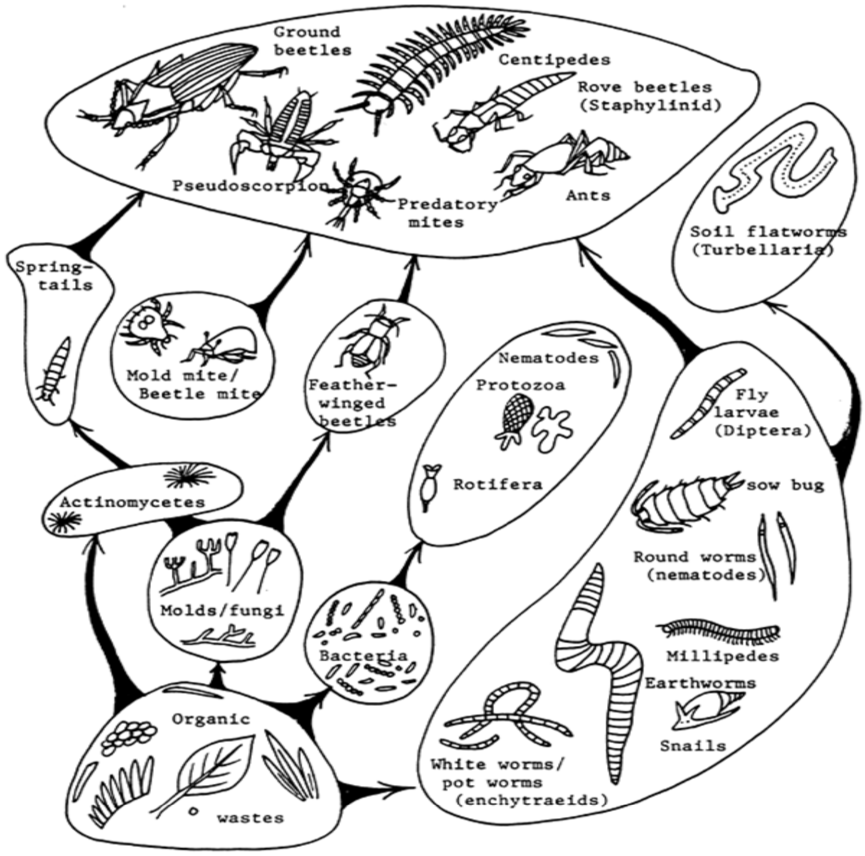

Figure 1 The organisms in the food web of the compost pile [29]

2.1.2 Important Parameters and Process Control

The Compost process is affected by many interlinked physical and biochemical parameters and is difficult to fully understand even for educated microbiologists. A basic understanding and process control is none the less important to prevent operating problems. The three most important parameters affecting the compost process are availability of oxygen, moisture, and temperature. To have a controlled and efficient process with a minimum of emissions these parameters should be controlled.[30]

Availability of Oxygen

Since composting is an aerobic process, the microorganisms that require oxygen are dominant. There are always pockets in a compost heap where the oxygen is depleted, and thus there will be some anaerobic organisms as well. In the case of insufficient aeration, these will grow and give rise to foul odours, lower temperatures and lower pH. In order to keep the process aerobic the oxygen deficient air in the compost heap must be replaced. This is done naturally, when hot air is moving up through the pile and fresh air from the surroundings is moving in to the pile. Turning facilitates this by structuring the material and making it porous so that air can move through the pile (see Figure 2). In some cases this is supplemented by some kind of forced aeration, i.e. blowing. The rate of the aeration required is affected by porosity and moisture content and the activity of the microbes.[31]

[29] Food and Agriculture Organization of the United Nations (2006-05-17)
[30] Manser & Keeling (1996) p. 142
[31] Ministry of Agriculture and Food Brittish Columbia (1996)

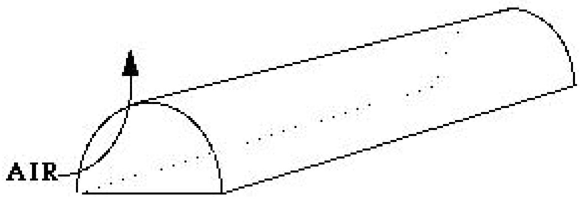

Figure 2 Air movement through a windrow

Moisture Level

Moisture is essential for a working process since microorganisms can only utilize organic molecules that are dissolved in water. A too low moisture content will thus limit the bacterial activity. A moisture level that is too high will reduce the space of air in the heap, and thus create anaerobic conditions and in that way also hamper the aerobic process, cause odours and leakage of nutrients.[32] Water is lost through evaporation, especially when the compost is turned, and thus it must be added during the process. The structure of the material is the dominant factor deciding the appropriate moisture level, since it affects the air space cavities in the heap.[33]

A simple way of estimating if the moisture content is within the right range is to do "the squeeze test". When squeezing a sample of compost in the hand, the compost should form a lump, without leaking water. The moisture content is then usually in the region around 40-60 percent[34].

Attainment of High Temperature

When compostable material is formed in a pile, the temperature often rises within a few hours. A rise in the temperature is a sign that the process is working well. There are lots of different types of microorganisms, which prefer different ranges in temperature. At the initial temperature of the compost heap the mesophilic bacteria are most active. These are favoured by temperatures between 10° and 45°C.[35] The activity of those bacteria makes the temperature rise further and above 45°C thermophilic bacteria are active. The fastest decomposition rate is occurring around 55°C[36], and temperatures above 70 °C will hamper the process. Another reason for keeping the temperature down is that loss of nitrogen in the form of ammonia gas increases with increasing temperature, affecting both the nutrient content of the product and the environment negatively[37]. Still, high temperatures, exceeding 55° C, are often desired for a period of time because it kills pathogens and weed seeds[38]. Since the temperature is not the same in all the material, this high temperature must be reached for a period of time while mixing of the compost ensures that all material is hygienised. If not all pathogens are killed, some types of pathogens can quickly grow in number and make the whole compost contagious again.

If the temperature drops in the compost it can either be a sign that the material has run short of oxygen, has become too dry or that the available nutrients have been consumed,

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[32] Ministry of Agriculture and Food British Columbia (1996)
[33] Haug (1993) p. 213
[34] Ministry of Agriculture and Food British Columbia (1996)
[35] Ministry of Agriculture and Food British Columbia (1996)
[36] Sundberg (2005)
[37] Ministry of Agriculture and Food British Columbia (1996)
[38] Manser & Keeling (1996) p. 142

and is thus a sign that the compost should be turned. Aeration and watering will initially lower the temperature of the compost, but will then give new rise to the process by supplying the microorganisms with better living conditions with more oxygen and moisture available. When turning of the compost no longer gives rises in temperature, the compost has reached a mature state, where all of the easily decomposed material is degraded, and the compost is ready. However, biological activity will never stop entirely, since slowly decomposable substances will still remain.

2.1.3 Technology

Outdoor composting in aerated windrows is a common technique that is suitable for green waste, possibly mixed with source separated kitchen waste. It is less suitable for more problematic wastes as abattoir wastes, human and animal excreta or wastes very rich in protein, i.e. dairy wastes, because of higher risks of odour, attractions of animals and for hygienic reasons. The more problematic the waste is, the more controlled must the process be, and enclosed composting might be necessary.

Aeration can either be done by forced aeration in a static pile or by mechanical turning. The main purpose of the turning is to maintain a good structure for self ventilation in the heap, but with some technologies water can be added simultaneously. Mechanical turning in large scale enterprises can be done in four ways[39]:

- Turning by front end loaders or other earthmoving equipment
- Special windrow turners, self powered or pulled by a tractor, that straddle along the windrow, and turn the compost without moving the position of the heap
- Using side cutting turners that turn the windrow by slicing layers from the side and rebuilding the heap in a new place
- Tumble the waste in a rotating conditioner drum before putting it in windrows

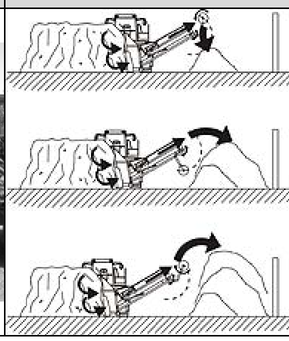
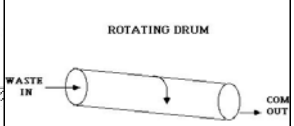
Front end loaders	**Straddle turners**	**Side cutting turners**	**Rotating conditioner drum**
			

Figure 3 Examples of different machines for turning compost

[39] Manser & Keeling (1996) p. 177

In Table 2 the advantages the advantages and disadvantages with each technology are given. In small scale composts there is also the option of manual turning. In developed countries this is seldom done in other cases than home-composting and therefore not included as an option in literature from these countries, covering composting of municipal waste. Vermi-composting is another option where worms structure the material so that no additional turning is needed. Vermi-composting is in several ways different than conventional composting.

When choosing technology it should be taken into regard that a high level of mechanical mixing and turning is beneficial to the process because it breaks bigger pieces down, evens out the temperature, and exposes new surfaces in the material to the biological activity. The limitations that the choice of equipment sets on the size of windrows is also important. Small windrows are more sensitive to weather conditions, and thus require more water and more management.[40]

Table 2 Advantages and disadvantages with different types of turning equipment

	Front end loaders	Straddle turners	Side cutting turners	Rotating conditioner drum
Advantages	Cheap and simple Machinery can be used for many purposes	Good mixing and break down of material Space efficient if self-powered	No limitations in windrow size Space efficient	Shortens the time needed in windrows
Disadvantages	Little mechanical mixing and break down of material Compact the material gives insufficient aeration Requires much space No watering	Limitations in size of windrows Requires much space if tractor pulled	Relatively high capital costs Only large scale	High capital costs Post-treatment with turning necessary

2.1.4 Use and Quality of End Product

Compost can be a valuable product in gardening and landscaping. The quality of the end product differs much depending on the waste treated and the technology used. One example of this is the nutrient content. High temperatures, high pH and frequent turning lower the nitrogen content since it will be released as ammonia gas during the composting process.

[40] Manser & Keeling (1996) pp. 155-162

The criteria for quality depend on what use the compost product is intended for and the status of the soil where it is to be used. Therefore general quality criteria can not be given but should be done nationally. In South Africa, compost that is marketed as a fertilizer is by law[41] required to be registered as a Group 2 fertilizer at the Department of Agriculture. To be granted a registration, a chemical analysis of the nutrient content of the compost must be submitted. There is, however, no specification on other parameters that should be measured, nor any criteria for acceptable levels of potential harmful substances in the compost.[42] The parameters presented below should be seen as a minimum requirement of what should be specified.[43]

Organic matter content: The organic matter content is a measure of carbon-based materials in the compost. Contamination with dust and gravel will lower this figure. High quality compost will usually have a minimum of 50 percent organic content based on dry weight, but it can be as low as 20 percent[44].

Moisture content: Low moisture content facilitate spreading of the product and prevent mould and malodour, the moisture content should be around 25 percent or less[45].

Inert material content: The content of (glass, plastic and particulate metal) will affect the appearance of the compost and will have direct impact on marketability, why this figure should be low.

Nutrient Content: The nutrient content should be high. The most commonly required nutrients are phosphorus, potassium and sulphur.[46] In general, nutrients found in compost are organically bound and not immediately plant available. However, they are released slowly as the compost decomposes in the soil.

Salinity: The salinity (Soluble salt concentration) is expressed as electrical conductivity (dS/m or millimhos per centimetre) of a saturated extract. Soluble nutrients, particularly potassium, calcium and nitrogen, typically account for most of the salinity in compost products. Sodium is an undesirable soluble salt.

pH: pH between 5 and 8 is acceptable.

Metal content: Trace levels of many metals are essential for the plants, but are toxic at to high concentrations. Especially the levels of lead, cadmium, cupper, chrome, mercury, nickel, and zinc should be specified[47].

The level of stability and maturity should also be given. A stable and mature compost has a low level of biological activity. Immature compost can contain naturally occurring substances that are poisonous to plants, (phytotoxins)[48]. Another disadvantage of

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[41] Act 36 of 1947
[42] South African Government Services (2006-06-19)
[43] Manser & Keeling (1996) pp. 284
Soil and Plant Laboratory (2006-05-23)
[44] Swedish National Testing and Research Institute (2005) p. 13
[45] Note that this figure is for the end product. The moisture content should be higher (35-60%) during the composting process
[46] Pernilla Tidåker, personal comment (2006-05-03)
[47] Swedish National Testing and Research Institute (2005) p. 13
[48] Manser & Keeling (1996) p. 285

applying immature compost is that nitrogen immobilisation can occur[49], resulting in lower levels of plant available nitrogen in the soil than before the compost was added. There are many proposed tests for maturity, but no one that is both simple and alone sufficient. Often it is enough to use the drop in temperature, possibly together with cress germination tests that indicate if there is phytotoxins in the compost.[50] Physical characteristics that are suggestive of a mature compost include a dark brown to black colour and a soil-like or musty odour. There should be little or no recognizable grass or leaves.[51] The compost should also be low in weeds and pathogens.

2.2 Environmental Sustainability

2.2.1 Impacts on Environment and Health of Yard Waste Composting

If not carefully controlled, the composting process can create a number of environmental and health related concerns. If the site is well managed, the impacts are small compared to the environmental impacts of landfilling, especially when the facilities are small scale and only treat yard waste. Still, it is important to be aware of the potential environmental effects. We will here give a brief outline of environmental impacts and health concerns that are connected with composting of general waste.

Water Pollution

The potential water degradation of compost facilities is connected with forming of leachate. Leachate is liquid that has percolated through the compost pile and that contains dissolved or suspended material from the pile. If allowed to run untreated from the composting pile, leachate can seep into and pollute ground water and surface water. Leachate from the composting of yard trimmings is a dark liquid with a high biochemical oxygen demand (BOD). High BOD depletes the dissolved oxygen of lakes and streams, potentially harming fish and other aquatic life. The leachate also contains naturally occurring phenols that are non-toxic but can affect the taste and odour of water supplies if they reach surface water reservoirs. Natural phenols and BOD do however not appear to pose a problem to ground water supplies, as they are reduced by soil organisms before reaching the aquifer.[52]

The leachate may cause an environmental problem if the waste treated is rich in nitrogen, since leachate can contain nitrate[53]. Nitrate contributes to eutrophication and can contaminate ground water. Nitrate contamination is the main reason for many groundwater resources to be declared unfit for drinking in South Africa.[54]

To avoid the risk of water pollution, leachate generation should be reduced or prevented by monitoring and correcting the moisture levels in the composting pile. The windrows or piles can be placed under cover to prevent excessive moisture levels in the wet season. The simplest way to handle leachate that is produced is to collect and reintroduce it into the compost pile. This should not be done once the composting materials have passed the high-temperature phase, however, as any harmful

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[49] Benito et. al. (2005)
[50] Manser & Keeling (1996) p. 286
[51] Soil and Plant Laboratory (2006-05-23)
[52] U.S. Environmental Protection Agency (1994)
[53] U.S. Environmental Protection Agency (1994)
[54] South Africa Water Reasearch Comission (2005)

microorganisms that were inactivated by the high heat can be reintroduced with the leachate.[55]

Air Pollution

Composts give rise to ammonia emissions which causes acidification and eutrophication. The only other emitted gas from a well functioning compost is carbon dioxide, which in the case of compost is neutral and does not add to the greenhouse effect. If there are problems in the process, causing anaerobic digestion, emissions of methane and nitrous oxide, very aggressive greenhouse gases, will occur.[56] In open composting, the gases can not be collected or treated. To prevent green house gas emissions the compost should have sufficient aeration.

The compost activities often include transport and machines that give rise to air pollution. The emissions can be reduced by organizing drop-off points to minimize queuing and transport and keep mobile equipment used at the facility well maintained to keep it operating cleanly.

Soil Pollution

If the waste is contaminated with toxic substances it will enhance the potential environmental impacts considerably. Possible harmful substances that might be found in the waste are metals and Persistent Organic Pollutants, such as polychlorinated biphenyls (PCBs), pesticides, and polycyclic aromatic hydrocarbons (PAHs).[57] PCB in the compost originates from treated wood, and PAHs are combustion products that due to atmospheric deposition can be especial high in foliage that have grown close to heavily trafficked roads[58]. Even if some toxic substances, for example PAHs, are degraded by the microorganisms, the compounds formed as a result of this process can be more toxic than the original PAHs[59]. PCBs and some pesticides are resistant to biodegradation and are generally not broken down during the composting process[60]. These substances can either leach out or stay in the compost. The concentrations are very low and will not have direct detrimental effect on soil or plants[61], but long term application of compost to soil might cause accumulation of Persistent Organic Pollutants and metals that can degrade the status of the soil[62].

Even metals that are beneficial to the plants in small amounts can be harmful in high concentrations. Metals are not broken down but accumulated in soil, and therefore a long term application of compost high in metals will increase the concentrations in soil, even if the concentrations in the compost are low. The composting process reduces the volume of the waste and therefore the concentrations of metals are higher in the finished compost than in the incoming material. The finished compost should be tested to make sure the levels are not elevated.

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[55] U.S. Environmental Protection Agency (1994)
[56] RVF The Swedish Association of Waste Management (2005b), s. 8
[57] U.S. Environmental Protection Agency (1994)
[58] Danish Environmental Protection Agency (2002)
[59] Larsson & Lind (2001)
[60] U.S. Environmental Protection Agency (1994)
[61] Ozores-Hampton, Stansly and Obreza (2005)
[62] Jordao, Cecon and Pereira (2003)

Bioaerosols

Since they are so small, some of the microorganisms from the compost process can be suspended in the air and remain there for a long time, creating biological aerosols (bioaerosols). These microorganisms can pose a health problem to persons that come in contact with them, especially to individuals with a weakened immune system. The bioaerosols of concern during composting include actinomycetes, bacteria, viruses, moulds, and fungi. Many of these colonize the incoming material at both yard trimmings and MSW composting facilities, and are readily dispersed from dry and dusty compost piles during and after mechanical agitation.[63] Resent research suggests that bioaerosols do not pose a problem for off-site neighbours, but that the concentrations on site during vigorous activities such as shredding and turning can give health problems[64]. Manual workers should therefore use dust masks or respirators when handling the compost

Odour

Odour can be a significant concern in composting, especially when putrescible[65] waste is treated. Odour is mostly a problem if anaerobic conditions occur. Even though this is not a threat to the environment, it might affect sensitive neighbours and cause a bad working environment on site.

Fires

If the compost material dries out and becomes too hot, there is a potential for spontaneous combustion to occur at composting facilities. Organic material can ignite spontaneously at a moisture content of between 25 and 45 percent. This is unlikely however, unless the material reaches temperatures higher than 93° C, which typically requires a pile over 4 meters high.[66]

Use of Natural Resources

In hot and dry climate, the amounts of water required to keep the moisture in the compost can be considerable. South Africa's available freshwater resources are already almost fully-utilised and under stress. At the projected population growth and economic development rates, it is unlikely that the projected demand on water resources in South Africa will be sustainable. Water is increasingly becoming a limiting resource in South Africa, and supply will become a major restriction to the future socio-economic development of the country, in terms of both the amount of water available and the quality of what is available[67] . Therefore water consumption is a factor that should be taken into account before initiating a large scale compost project.

2.2.2 Legal Requirements

In the Constitution of South Africa it is established that the citizens of South Africa have the right to have the environment protected and to live in an environment that is not harmful to human health or wellbeing. One of the legal instruments developed to ensure that this right is given effect to, is the Environmental Impact Assessment (EIA).

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[63] U.S. Environmental Protection Agency (1994)
[64] Sanchez-Monedero et. al. (2005)
[65] Liable to rot or become putrid
[66] U.S. Environmental Protection Agency (1994)
[67] DEAT (1999b)

EIA is the responsibility of both national and provincial government institutions. Policy formulation and coordination takes place at national level, while approval of EIAs for development proposals is the responsibility of the provinces. The provinces may, in turn, devolve this competency to their local authorities.[68]

An EIA is from 2005 legally required for all waste treatment facilities taken into use after May 2002[69]. Unauthorised continuation of activities identified in terms of the Environment Impact Assessment Regulations, or failure to comply with conditions of an environmental authorisation issued may be subjected by a fine or imprisonment.[70]

In the process of a full EIA, a description of the project and how it may affect the environment and alternative solutions are presented to authorities. Thereafter the remainder of the environmental impact assessment is conducted by an independent external consultant.[71] When the authority believes that it is unlikely that the activity will result in any significant environmental impacts, it is considered appropriate to issue an exemption rather than a permit. This is very common for activities related to the recycling and/or the treatment of waste, for example where the applicant wishes to recycle waste material into a commercial product. With an exemption the EIA process is shorter. [72] In the case of composting projects the EIA takes into account the environmental impacts and is specifically concerned about questions like construction and placement of the site.

2.3 Economic Sustainability

One of the most important questions for the municipalities is the economic sustainability of the project[73]. There are differences in availability of financial, natural and human resources in the South African municipalities, and many of them have very limited capacity to supply the citizens with basic municipal services.

When looking at the financial aspects of composting projects, we have chosen to use the term "economic sustainability" in order to distinguish the economic objectives from profit-oriented business. While the main objective of most private companies involved in composting is to make profit, the municipality usually has a broader perspective on the economy of the operation. Being able to provide the citizens with e.g. a healthy environment is of great value, even if this value is hard to specify in financial figures. The awareness that there are many costs and benefits that are not incorporated in the contemporary economic market is growing. And efforts are made in order to get governments and corporations to start to look at these non-market values and external costs[74]. That is why it is important for this study, which has the municipal approach as point of departure, to evaluate the economic sustainability of composting projects in this broader term.

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[68] SAEIA, Southern African Institute for Environmental Assesment (2003) pp.9
[69] DEAT (2005)
[70] DEAT (2005)
[71] South Africa Government Notice. R. 1183 (1997)
[72] DWAF (2002)
[73] Personal comment, Ken Kendall meeting at NMMM, 2005-11-05.
[74] United Nations Agenda 21 (1992), paragraph 4.6

2.4 Social Policy Fulfilment

During the years of Apartheid the non-white South Africans were systematically shut out of the economy. The dispossession of land in the late 1800's, the Mines and Works Act from 1922 and the Apartheid laws from 1948 made access to education, skill enhancement and self-employment only achievable to a small minority of South Africans, leaving the majority of the people forced to participate as cheap labour with little chance to improve their situation.[75] The inequalities led to a situation where the white minority possessed a high living standard, and the majority of the population were living under conditions characteristic of developing countries.[76]

South Africa has undergone large changes since the first democratic elections of 1994 put an end to the Apartheid system, but socioeconomic structures are not changed over night and the structures of inequalities still affect many areas of society.[77] South Africa is still one of the most unevenly income distributed countries in the world.[78] One example of this is that the unemployment rate of black people is 28 percent compared to 4 percent among the white population[79]. This should be seen in the perspective that South Africa has a population of almost 47 million people of which only 9 percent are white[80]. Even though South Africa is the richest country in Africa and is classified as a middle income country with advanced infrastructure, modern technology and large natural resources, almost half of the total population is poor.[81] Statistics from UNDP clearly demonstrates this problematic situation, as South Africa has a relatively high BNP per capita, but only small part of the population has access to clean water and medical help[82].

The major challenge for the government of South Africa has been to reduce the uneven distribution of financial and intellectual property in the country and the inequalities that this renders in terms of access to education, jobs and economic means between white and historically disadvantaged people (HDP). In order to do so the South African government has, apart from legislation on basic human rights for all South Africans, decided on national strategies for job creation and poverty alleviation. One of the strategies is to support the growth of co-operatives, especially among historically disadvantaged South Africans, specified in the Co-operatives Development Act that was passed in August 2005.[83] Another strategy is to increase investment in education and training, right historical wrongs regarding access and opportunities to learn, and encourage employers to use their workplaces as active learning environments in the Skills Development Act (1998).[84] The most important strategy is the Black Economic Empowerment act (BEE). This strategy strives to adjust the inequalities by giving direct priority to previously disadvantaged groups in the economy.[85]

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[75] Department of Trade and Industry. BEE, (2006-04-15) p. 6
[76] Swedish National Encyclopedia (2006-03-15)
[77] Department of Trade and Industry. BEE, (2006-04-15) p. 6
[78] SIDA (2006-03-10)
[79] 2001 South African National Census
[80] Statistics South Africa (2005)
[81] SIDA (2006-03-10)
[82] UNDP (2005)
[83] The Small Enterprise Development Agency (SEDA) (2006-05-18)
[84] Wagner & Stacey (2001)
[85] Exportrådets landfakta

2.4.1 Black Economic Empowerment

The Black Economic Empowerment (BEE) act states that companies working in South Africa have to take direct action in letting black and coloured people into the economy and gives key figures on required black representation in different company levels.

To enhance the possibilities of previously disadvantaged groups' entrance into the economy The National Small Business Act, which was introduced in 1996, promotes the development and strengthening of small businesses. This constitutes part of the national efforts to build institutions that provide financial and other support to small businesses. A large proportion of the funding has been directed to support black entrepreneurs.[86]

Another policy document in this field is The Green Paper on public sector procurement report which was outlined in 1997 and called for the government to direct their consumption of goods and services according to the policies of Broad Based Black Empowerment, and job creation by promoting small enterprises and labour-intensive constructions.[87] In order to meet these goals the tendering process has been reformed. It is made more accessible to black people and smaller tenders have been developed in order to give small enterprises a chance to participate. Since 2000 all public sector procurements must take this into account by law of the Preferential Procurement Act.[88]

BEE Scorecard

In order to implement the strategies promoted by the BEE act a point system has been developed giving companies supporting the BEE policy's target group advantages in the competition for tenders. This point system is measured by BEE – scorecards. The company can get a score between 0 and 100. This figure will be the BEE status of the company and corresponds to its acts and contributions in this area. The larger the figure, the better is the BEE status.[89]

From BEE to Broad Based BEE

One of the essential factors affecting a company's BEE-status is the company ownership by previously disadvantaged people. This has led to a situation where many companies have changed their owner structures. However, there have been problems that the outcome has not been stringent with the vision of the policy. In many cases the change in ownership structure is merely a strategy by companies competing for municipal and government tenders. The new owners often give shares of the company for free without any real structural change in the company taking place.[90] This misinterpretation and misuse of the BEE strategy is referred to as fronting[91]. The problem with fronting has led to a situation where a few black businessmen can make a lot of money, while the real problem consists.

This criticism has resulted in new formulations and new guidelines of the policy to stress that changes need to be made on a more structural level. In 2004 the Broad-Based

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[86] Department of Trade and Industry (2005a) p. 8
[87] Department of Trade and Industry (2005a) p. 8
[88] Department of Trade and Industry (2005a) pp. 8
[89] Department of Trade and Industry (2005b) p. 8
[90] Department of Trade and Industry (2005b) p. 2
[91] Department of Trade and Industry (2005c)

Black Economic Empowerment (Broad-Based BEE) Act was enacted,[92] and the work of formulating *Codes of Good Practice* was initiated, with the purpose of clarifying the measurements of BEE. By doing this the government hopes to assure that "economic substance takes precedence over form". The government also hopes to get a comparable measurement of BEE between different entities in order to further strengthen the grade of competition based on BEE contribution. In this way the public and private sectors will be forced to take this matter seriously in form of direct actions.[93] These new guidelines will be finished in 2006 and the Code of Good Practice will be binding for all organs of state and public entities in the areas of procurement, licensing and concessions, public private partnership (PPP's) and sales of state-owned entities[94].

The new term Broad-Based BEE has also been chosen in order to further emphasise that this strategy is not only referring to black people but all historically disadvantaged people, including coloured, women and disabled. An overview of the seven elements which the new broad-based scorecard is based on is shown in Figure 4 below. The weighing characteristic for the scorecard, in form of a percentage, is also shown under each area.[95]

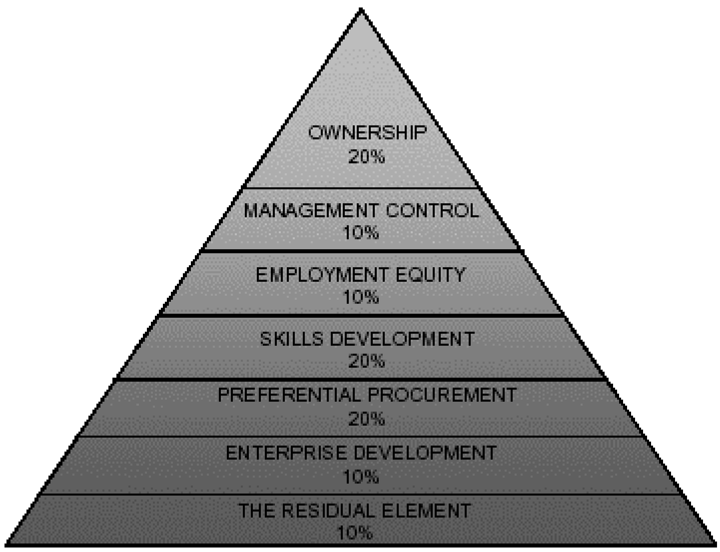

Figure 4 The seven elements of the broad based BEE score card[96]

[92] Department of Trade and Industry (2005b) p. 2
[93] Department of Trade and Industry (2005b) p. 11
[94] Department of Trade and Industry (2005b) p. 2
[95] Department of Trade and Industry (2005b) p. 2
[96] Department of Trade and Industry (2005b) p. 4

3. Results - The Municipalities and the Compost Projects

In November 2005 to February 2006 we visited seven composting projects in the five municipalities of Cape Town, Johannesburg, Sol Plaatje, Makana and Breede River Winelands Municipality. In this chapter the compost projects are described. To give a background to the conditions under which the project is operated, a short description of the municipality where the project is located is first given. If no other sources are stated the information derives from interviews and visits at the projects. In order to utilise a comparison between the different projects a summary of some of the information is given in tabular form at the end of this chapter.

3.1 Cape Town Municipality

With a population of about 3 million, Cape Town is one of the three largest cities in South Africa. It is a commercial and industrial centre with both process and manufacturing industries. The average living standard is high and the rate of unemployment low compared to other areas in the country. In the area around Cape Town the agricultural sector is well developed and has considerable export of fruit. International demands for organic products have given rise to an awareness of advantages in using compost and a hands-on-knowledge about how to produce it in the agricultural sector. It has also stimulated research in the field at the universities.

The Cape Peninsula has a Mediterranean climate with mild winters with an average minimum temperature of around 7°C, and hot and dry summers. Most of the city's annual rainfall occurs in wintertime, but due to the mountainous topography of the city, rainfall amounts for specific areas can vary dramatically. The valleys and coastal plains average 500 millimetres of rain per annum, while mountain areas can average as much as 1500 millimetres per annum. The Peninsula gets frequent strong winds from the south-east.[97] The warm climate is favourable for composting all year round, but the hot and windy summer weather put high demands on water supply for the compost.

Situation of Waste Disposal

In 2004 2.3 million ton of solid waste[98] were collected and treated in Cape Town Municipality. 120,000 tonnes was pure green waste, and of this 30 percent was composted. A further 31,200 ton of mixed house hold waste was treated in the municipality's own facilities. All together 2 percent of all waste was treated biologically as an alternative to landfill.[99]

The waste situation in Cape Town is very constrained with approximately eight years of remaining landfill capacity. A new regional landfill is planned, but it is hard to find a nearby location that is acceptable to the public. To save space in the existing landfills and, in the future, to lessen the costs of transport, it is a highly prioritised goal for the municipality to minimize the waste going to landfill. One way of doing this is to separate the stream of green waste and treat it biologically.

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[97] BBC Weather (2006-05-07)
[98] Including domestic and commercial wastes
[99] City of Cape Town (2004) Chapter 5 p.14

Organisation and Financing of Compost Project

The municipality has treated mixed wastes in municipal compost plants since 1969. When starting up the separate handling and treatment of green waste, the municipality chose a solution involving Private-Public Partnerships. The municipality owns the drop-off sites, where the green waste is received, and puts out tenders for the management of those. The contractor undertake, not only to manage the receipt and chipping of green waste, but also to manage the entire site and the subcontractors, that are appointed by the City, to take away and treat other fractions of waste that are received on the site. The contractors are compensated for the site management and for to the amount of chipped green waste they take care of .

The operational costs that the municipality has for the composting done by the private contractors is R38[100] per ton of unchipped green waste[101]. This can be compared to the operational costs for compositing in the municipal composting plant that are R280-R480 per ton, and for landfill that ranges between R10 and R70 per ton.[102] The composting of the green waste had facilitated a direct operating budget saving of more than R8 million in three years. This figure is calculated as the difference in the price of chipping the waste stream and transporting it to a composting site and traditional transporting and landfilling charges. If both capital and operational expenditure is taken into account, the airspace cost is R150 per cubic metre, and the savings is even larger, but exactly how large is not calculated.[103]

Cape Town Municipality has chosen this design with private contractors since commercial composting is not identified as part of their core activities. The municipality is satisfied with the arrangement. In general, the management of drop-offs under the control of council was between poor and acceptable, the main problem identified being screening of incoming waste and tidiness.[104] There has been a noticeable improvement since operation being taken over by a private operator, as well as a significant increase in the quantities of green waste being diverted from landfill.[105] Still, a third of the green waste collected on the drop off sites goes to landfill, because of insufficient sorting or because the material cannot be chipped without damaging the chipping equipment.[106] The Municipality has received support from Municipal Infrastructure Investment Unit for construction of the four drop-off sites.

3.1.1 Radnor and Bellville South

The municipal composting plants Radnor and Bellville South have a similar construction and are managed by the same actor. Therefore they are presented together. Radnor and Belville are municipal composting plants that came into operation 1969 and 1972 respectively. The plants are run without a formal permit from the Department of Water Affairs and Forestry (DWAF) and there have been complaints about the operation and the products of the plants. In order to apply for a permit, the municipality let an external consultant evaluate the plants a few years ago. The resulting report

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[100] City of Cape Town (2004) Chapter 5 p. 5

[101] This figure is calculated on the assumption that 1 m3 of chipped green waste equals 4 m3 of unchipped waste, and that 1 tonne of unchipped green waste has the volume of 5 m^3.

[102] City of Cape Town (2004) Chapter 5 p. 5

[103] Morkel (2005) p.16

[104] City of Cape Town (2004) Chapter 7

[105] City of Cape Town (2004) Chapter 5 p. 15

[106] City of Cape Town (2004) Chapter 5 p. 14

recommended that the plants should be shut down because they did not comply with environmental or working safety regulations. However, the municipality decided to let them run for some time to ease the constrained landfill situation.

Type and Collection of Waste

The two plants receive in total 62,400 ton of mixed household waste per year, but about 50 percent is sorted out in the process and taken to landfill. The waste is collected at nearby households, offices and factories. The plants have an annual production of 19,000 ton and 9,500 ton of compost per year respectively. [107]

Process

The plants are slightly different in their process setup. In Belville the material is put on a conveyor belt and subjected to manual and magnetic sorting before it is size reduced, screened and put into windrows. At Radnor the waste is discarded in trenches before it is size reduced in a hammer mill. The waste is transported on conveyor belts to a Dano® rotating conditioning drum before it is screened and put into windrows. In the original design the material was supposed to be watered and aerated while passing through the conditioning drum before it was put to stabilize in windrows. At present the management of the drum fails to fulfil this. The watering is kept at a minimum to prevent the material from clogging on the conveyor belt. Also the aeration is insufficient since the drum only rotates a 4-8 hours a day, causing the process to go anaerobic in the nights and during weekends. When running the retention time in the drum is about 30 minutes. Another factor that makes the technical design inadequate is that the organic content of the waste is much lower today than in the seventies due to an increase in the presence of inorganic materials, e.g. plastics.

Figure 5 Incoming unseparated waste

[107] City of Cape Town (2004) Chapter 5

When the material is put into windrows, they are turned and watered about once a month. The temperature does not reach thermophilic temperatures, but stays within the range of about 39-42° C, which suggests that the compost is not hygienised. Test piles with higher organic content get, according to our measurements, a better rise in temperature, but are also watered and turned more frequently. It is thus not clear whether it is the composition of the waste or lack of process control that is the inhibiting factor.

End Product and Market Issues

The compost that is produced is not tested or certified. Even if the bigger pieces of plastic and glass are screened out, it still contains small pieces. The finished product is bagged and sold at the site to homeowners. Since the municipal operator is aware of the poor quality of the product it is not marked as “compost” or “fertilizer”, but as “soil enhancer”. Although there is some development work going on to improve the composting process, the product will in the future only be used for the city’s internal use, in parks and as cover on landfills.

Social Policy Fulfilment

The plants employ 27 persons permanently, but the jobs created are not healthy. In the future, compost will be given away for free to community gardening projects.

Environmental Impact

The plants do not have permission from DWAF and no Environmental Impact Assessment has been done. The major problems with the plants are that they constitute a dangerous work environment. Since part of the process is performed indoors, we find it to be very likely that workers are affected by dust and bioaerosols formed in the process. There has been complains from neighbouring enterprises about smell, which indicates that the process at times turns anaerobic and thereby probably produce methane. The plants have concrete surface, but the leachate is not collected or treated.

Apart from these direct impacts, one large concern is the waste itself. With the insufficient separation it is much likely that the produced compost contains substances that might pose a long term threat to the soil quality where it is spread. However, the municipality deems that the environmental benefits with reducing the waste on landfill outweighs the negative impacts, and thus continue with the operation while investigating ways to improve the situation and the end-product.

Future

Since October 2005, the municipality in cooperation with a private company is performing trials in order to enhance the process at Radnor. The idea is to increase the organic fraction of the waste by mixing it with food waste from markets, and add “multienzymes”. The result is still to be evaluated.
Trials with a source separation system for households, where the organic fraction is put in coloured bags, have also been undertaken, but so far with limited success.

3.1.2 Reliance

Reliance grows grapes for the international market. When the company converted to organic farming in 1998 they started composting to fill their own need for an organically approved fertilizer. In year 2003 Reliance became a contractor to the municipality and started composting municipal green waste.

Type and Collection of Waste

Reliance treats about 500,000 m^3 of green waste per year. Most of the green waste is collected at the three public drop-off sites that are managed by Reliance. The waste is chipped on the drop-off site by a subcontractor and then transported to one of the three compost sites, where it is stored before treatment. In season Reliance receives vegetable wastes and fruit residues from the grape industry directly at the site. The vegetables cannot be stored but must be treated immediately while the grapes must be mended in gradually not to cause a rise in iodine and potassium in the compost. Reliance produces about 60,000 m^3 of compost and mulch per year.

Process

The chipped waste is mended with inoculums and put into 1.8 meter high windrows. The ambition is that temperature and CO_2 emission should be measured daily, and used for deciding turning intervals, but with growing quantities the operator tend to use standard times. Turning and watering is done by a tractor pulled straddle turner. The compost is considered ready when the temperature falls to ambient and the company's own laboratory tests show it has the right pH value, and are low in the phytotoxics NO_2[108] and H_2S. The whole compost process takes 6-8 weeks. The ready compost is then sifted and bagged, or sold in bulk.

The main problems encountered are that the machines are under-dimensioned, that the temperature rises too high and that the windrows dry out in the hot season. To avoid this, the windrows are turned as often as every day. In the cold season the windrows are covered to prevent them from getting too wet. The water is taken from dams that are also used for irrigation of nearby fields, and the water pressure can be low in the hot season.

End Product and Market Issues

Reliance produces different types of compost, such as plant feed, soil conditioner, lawn dressing, potting soil etc, and mulch[109]. Besides their own use of the product the main customers are landscapers. The bulk price per cubic metre is R187 for compost and R50 for mulch. The price for wood chips that have not been composted is R45. The company has a reputation for producing a high quality product and the compost has previously been organically certified.

Since the dwellings and businesses in the area around Cape Town are in a phase of expansion, there is a lot of construction work going on. The company therefore has no

[108] NO_2 was measured with cress-tests.

[109] Reliance, as many other producers, market their end product as Soil Feed and Plant Feed etc rather than "compost" in order to distinguish themselves from other producers with lower quality on their product. Due to poor regulation and there is a lack of standards for the quality of commercially sold compost.

problems in finding customers. The relations with many of the customers are on long term basis, with a monthly selling of compost. Reliance is also a retailer for composting equipment to farmers and private and public composting projects.

Figure 6 One of Reliance compost sites

Social Policy Fulfilment

There are about 26 persons involved in the waste handling and composting sites, of which 4 are working in administration. Nine of the employees are women, including one female site manager. The company has a traditional structure with only whites and a few coloured working as managers and in administration. The workers on the sites are black unskilled labour, but get informal training in managing the compost. There have been trials with letting the workers become shareholders in the company, but they are now bought out. To be able to comply with the BEE regulation the company has formed joint ventures with companies with a higher BEE status than their own.

Environmental Impact

Environmental concern is a part of Reliance's business concept and the very reason for starting the compost project. The environmental impacts that the compost might pose are deemed negligible. The compost sites are not paved and leakage is not collected why the site can be wet and muddy during the wet season. In the wet season, however, the windrows are usually covered and this should prevent excessive amount of leachate forming.

A drilled well is under construction to be able to use ground water and in the summer the high need for water can add the constrained situation with sinking levels of ground water in the area.

Future

The amounts of municipal waste that are to be treated biologically are growing in Cape Town and Reliance has put in tenders to increase their undertaking. The company also has plans of expanding in other regions and countries. The international trade with green house gas emission credits is also seen as a factor enhancing the potential of the composting business. One of the greatest challenges for the company is to up-scale without loosing in quality. The rigid methods for monitoring the process and ensure a high quality might prove too expensive for large scale handling.

3.1.3 Earth to Earth

Earth to Earth is part of the national waste company Interwaste which is well established in the waste business. The company transports and handles different kinds of commercial waste. Interwaste was the first to respond to the municipal tender for chipping green waste in 2002. In 2005 they started to compost some of the chipped material themselves instead of selling it to other compost companies. About the same time Interwaste also started to undertake composting in their branches in Durban and Johannesburg. At this point it is only in Cape Town that they are treating municipal waste. When expanding their undertaking to include composting, Interwaste merged with a small compost company in Durban and the subsidiary company Earth to Earth was formed.

Type and Collection of Waste

Earth to Earth chips about 72,000 m^3 of green waste annually in Cape Town. The company does not compost all of this itself, instead some is sold to other compost producers. The chipped green waste is collected at the two public drop off facilities that are managed by the company itself. The fine green waste is not chipped but put into the compost directly.

Process

The chipped material is mixed with 0,3 kg Urea or fertilizer per cubic metre of chipped waste. A front-end loader is used to form large stacks. After 2-3 weeks the windrows are watered and turned. The temperature is measured occasionally, but in practice not used for monitoring the process. The reason for this is, according to our observations, that at this stage there is not enough space, equipment and human resources for controlling the process. After 12-15 weeks the compost is considered to be ready, even if the stacks are still producing heat. Some of the compost is sifted and sold, but since the sift is old and often broken, most of the material is sold unsifted.

End Product and Market Issues

The quality of the end product is lower than the competitors' and therefore another market sector is targeted. Most compost is sold unsifted and immature. The product is not certified and not marketed as a fertilizer since it is considered low in nutrients. Sifted compost is sold at the price of R90 per cubic metre and mulch is sold at R120 per cubic metre. Unprocessed chipped green waste is sold at R55 per cubic metre. According to the site manager this price is low and not reflecting the work put in to the production of the compost. There is no problem in selling the compost and most of the customers are landscapers.

Environmental Impact and Location

By establishing at a site of a former compost facility Earth to Earth could use the existing permit why no EIA is done yet. The site is situated in an area close to the city where there traditionally has been much agricultural activities. The advantage of the location is that it is close to the source of waste and end users. Since the site is on an aquifer there is also good supply of water. The disadvantage is that the site is not fenced and therefore has a problem with illegal dumping from nearby industries. The surface is not hardened and in the cold season the site can be flooded. In summer the site is very dusty, affecting the work and living conditions of the workers who live at the site. The loose monitoring of the process makes it likely to turn anaerobic from time to time, producing methane gas.

Social policy fulfilment, work creation and poverty alleviation

The compost plant employs four non-white persons, and one white site manager. They are all men. The workers are unskilled, but get informal training in running and maintaining the machines. To comply with the municipal demand for 40 percent black ownership, Interwaste form joint ventures with other companies with higher BEE status. The company has also given shares away to get a more balanced ownership.

Future

Interwaste has identified composting of waste as a future market with high potential and therefore has the ambition to develop their composting technology and expand on the national compost market. Even locally, the branch in Cape Town has noticed a growing interest when receiving inquiries from retailers as far away as in Port Elizabeth. The company is still in the learning stage, encountering problems of getting the process right and to build a sufficient resource base of both physical and intellectual property.

Figure 7 Compost sold on site

3.2 Johannesburg Municipality

Being the most populous city of South Africa, Johannesburg is a comparatively resourced municipality. The population of the city itself is more than three million, but the population of the Greater Johannesburg Metropolitan Area is almost eight million.[110]

Johannesburg has an annual average rainfall of 600-800 millimetres and most of the rainfall is in the hot summer months, whereas the winter is mild and dry. The average minimum temperature in winter is 4 °C, and the temperature occasionally drops below freezing, causing frost.[111] The weather is thus suitable for outdoor composting.

The growing population and economic development place pressure on the water resources and continued economic and population growth is dependant on schemes to divert water from other regions of South Africa.[112] Groundwater, like surface water, is often vulnerable to pollution. High concentrations of nitrate, originating from pit latrines in informal settlements, cattle farms, sewage plant effluent and excessive agricultural fertilization, have been found in groundwater systems in the area.[113] Thus both the use of fresh water and the quality of leachate must be considered when projecting a compost facility.

Situation of Waste Disposal

In the Johannesburg Metro 1,2 million tons of waste is treated annually by the municipally owned company Pikitup. Most of the waste is ending up at the company's five landfills. They estimate that about 250,000 tons is green waste and that 10-15 percent of this is composted.

As in many other cities of South Africa, the City of Johannesburg is in the process of substituting old landfills with new ones. One of the City's five landfill sites is to be closed in a near future and due to a negative public opinion it is hard to find a nearby location for the new landfill, resulting in high transport costs added to the waste treatment costs involved in landfill. The direct cost for landfill is approximately R35-R40 per ton, excluding transport. With a remaining landfill space enough for 70 years the situation is less immediate than in for example Cape Town. The driving force behind the ambitious investment in composting is instead partly that the Municipality of Johannesburg is working pro-actively for environmental sustainability.

Organisation and Financing of Compost Project

Plans for the compost project started when the city hosted the World Summit on Sustainable Development in 2002. At one point in the process of establishing composting of waste, the municipal waste company Pikitup put out a tender to find a private contractor. As they did not receive any offer they considered to be of sufficient standard they decided to run the facility as a division in the company. The garden sites, where the green waste is collected, existed before and are not a part of the compost division, even though they work in close collaboration. The compost division does not charge the regional divisions operating the garden sites for taking their green waste,

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[110] 2001 South African National Census
[111] BBC Weather (2006-05-07)
[112] Department of Agriculture, Conservation and Environment (2004) Chapter 6 p. 51
[113] DWAF (2006-03-11)

while there are charges internally for the waste they put across to landfill, which creates incentives for the drop off sites to sort out as much green waste as possible. The cost of transporting the waste is allocated to the regional divisions operating the garden sites.

When setting up the compost site the municipality received funding from a governmental fund for municipal infrastructural investments. The operation has during the first five years been financed by the refuse collection fee. In 2005 the sales of compost covered 65 percent of the costs and calculations indicate that the project will break even in 2006. When calculating the cost and benefits in the project, the company does not allow the compost division to take into account the savings that they generate for the company when diverting waste from landfills, savings in transport, external effects of branding or efforts in creating a public goodwill towards the company and waste minimization and recycling in general.

3.2.1 Pikitup

Type and Collection of Waste

The waste is collected at five of the 48 garden sites in the municipality. Today the five sites accept many different fractions of waste, but the aim is to transfer them into pure green waste stations. In 2005 the compost site received 95,000 m^3 (19,000 t) unchipped waste which resulted in 12,000 m^3 (7,600 t) compost.

Process

Most of the waste is stored and chipped at the compost site, with a surface area of about 40,000 m^2. It is then put into either small windrows or large windrows called trapezoids. Both types of windrows get a sufficient rise in temperature. The site manager favours the large windrows since they get higher temperature for a longer time and are less liable to dry out and therefore more apt to break down the hard wood in the waste. Two unexpected problems with the large windrows have been that they are attractive, both as a concealment for stolen goods and as sleeping place because of the temperature building up. Both these problems were solved by fencing.

The compost is turned and watered with tractor-pulled straddle turner, a self powered turner or, in the case of the large stacks, with two self-powered machines[114]. Pikitup also has an imported side cutting turner which has not been in use for some time, due to long delivery time for spare parts.

In the small stacks a drop in temperature to ambient is taken as a sign of the compost being ready. This takes about 14-16 weeks. In the large stacks, the process is interrupted before the temperature drops. The compost is then sifted and the large pieces, about 30 percent of the volume, are mixed with new waste to form new stacks, while the fine material is bagged or sold in bulk. Mulch is produced by just wetting and piling pure wood chips to let them darken.

End Product and Market Issues

Today Pikitup produces compost and mulch. The compost is certified as a class two fertilizer, and even though the registration does not require it, the product has been

[114] Ritlee Xecutech Sales & Service (Pty) Ltd (2006-03-17)

tested in an external lab to check the quality. The ash content is not measured, but estimated to be high because of high contamination of dust in the compost. The product is mainly sold in bulk to homeowners and there is a great demand, which is both due to low humus content of the soil in the area and as a result of the company's marketing efforts. The competition on the nursery market is harder, but Pikitup will broaden their range of products in order to compete with the private companies in this field. The price for one cubic metre of compost is R100 in bulk, R233 in bag. Mulch is sold in bulk at R120 per cubic metre.

Figure 8 Pikitups selfpowered straddle turner manufacured in South Africa

Environmental Impact and Location

The compost site is situated on the site of a former compost facility that treated sewage sludge, and therefore Pikitup did not apply for a new permit. For the new facilities. that are planned on other locations, Pikitup has entered the process of doing a full EIA.
The Panorama site is situated close to living and shopping areas. This far there has not been any complaints about odour which indicate that the process does not turn anaerobic and there should be a low level of greenhouse gases.

At the time of our visit the ground surface was not even nor graded, so the run-off water formed puddles and the site can at times be so wet that the turning is hindered[115]. The surface will not be paved but work on evening and hardening the surface was about to start. Since the compost site is situated on a closed down landfill, future sinking of the ground can be expected, and thus the problem might arise again. The surface runoff from the site will in the future be lead to the same watercourse as the run off water from the landfill. From there it will infiltrate into the ground. There has been no investigations on the quality of the leachate or if it contaminates ground or surface water.

[115] Ritlee Xecutech Sales & Service (Pty) Ltd (2006-03-17)

Social Policy Fulfilment

The company is BEE compliant and job creation is an important goal in the project, both by direct employments and by creating "entrepreneurship down the line". Today the site employs 16 persons, of which 14 are non-white, and un- or semi-skilled. Entrepreneurship is encouraged by helping individuals to sell the compost. Today these persons are appointed informally, but in the future a formal tender procedure will be used.

The work environment is good, with low degree of heavy manual labour, a roofed area for manual work and with in-door facilities for the staff. The project has few female workers.

Future

The priority for Pikitup is to increase the volumes of compost in order to financially break even. The company is planning to expand their undertaking by establishing two new compost facilities. There are also plans to start experimenting with composting of other kinds of waste than green waste.

3.3 Breede River Winelands Municipality

Breede River Winelands Municipality is a small municipality of 81,000 persons, encompassing the towns of Robertson, Ashton, Montagu, McGregor and Bonnievale. The percentage of unskilled persons and persons with an income below the minimum wage is high.[116]

The Robertson District's lime rich soil makes it eminently suitable for grazing for race horse stud farming and also for growing wine. The climate is similar to Cape Town, but with even less rainfall, around 400 millimetres[117].

Situation of Waste

Households in Robertson get their waste collected weekly[118], and 91 percent of the 28,800 tons of waste produced is collected and treated. In 2000 the landfill in Robertson was full and had to be closed down. The waste was transported to the landfill in Ashton, but realizing that this solution was not sustainable, the municipality hired a consultant to develop an integrated waste management plan. The resulting report included plans for a compost site, as well as a Material Recycling Plant at a new landfill. The work with establishing the landfill is still under way.

Organisation and Financing of Compost Project

When starting up the compost project, the municipality first opted for a private-public partnership with a local company operating the site. The company received a monthly subsidiary of R36,000. After two years the municipality rescinded the contract because of an insufficient level of equipment maintenance. Instead the company Reliance was contracted. Since this contract did not enclose any subsidiaries, the contract was discontinued by the contractor because of deficient profitability. According to Reliance,

[116] 2001 South African National Census
[117] BBC Weather (2006-05-07)
[118] Breede River Winelands Municipality (2006)

the amounts of waste received did not correspond to what the municipality had promised, and thus the project was too small scale to be profitable.
Today the municipality is operating the compost themselves, with the aim of converting it into a co-operative in the future. Income from selling the compost does not cover the expenditures at this small scale and the deficit is covered by the municipal budget. The direct costs (operational costs) for composting waste is more expensive than putting it on landfill. When taking the indirect costs (capital costs) and the income from sold compost into account composting is economically preferable to landfilling.

3.3.1 Robertson Compost

The planning and development of the compost project started in 1999 and in the year 2002 it was running properly.

Type and Collection of Waste

The waste is brought to the site by the generators, which are mostly homeowners in the area. Staff on site sort the waste into different fractions. The fine waste, as clippings and leaves, are not pre processed. Hard Acacia trees are sorted out not to harm the chipper. The remaining material is chipped. About 7,200 tons of green waste are treated per year, which renders about 1,200 tons of compost.

Figure 9 A bucket load of green waste is dropped at the compost site

Process

After chipping, the compost is put into 8 to 10 small windrows. Two kg of manure or blood are used per cubic metre as a starter and are put on the top of the windrows before mending. The windrows are turned and watered when the temperature reaches 65-70°C, which is daily in the hot season. A tractor-pulled straddle turner is used for turning and watering, and the water is taken via a municipal water pipe. The compost is considered ready after eight weeks, regardless of the temperature.

End Product and Market Issues

The compost is sold in bulk to homeowners. Even though no marketing of the compost is done, all that is produced is sold. The reason for this is believed to be both the educational campaigns about compost run by the municipality and that the gardeners are influenced by the agricultural sector which in recent years has increased their interest in organic methods of cultivation. No lab tests have so far been done on the end product. The compost is sold at R114 per cubic metre which is cheaper than the local competitors.

Environmental Impact and Location

The compost site is situated on the outskirts of Robertson. The municipality will wait with the entering of the EIA process for the compost site and instead do it in connection with the EIA process for the new landfill and Material Recycling Facility. The site that is used today has no collection of run off water, but due to the dry climate there is seldom any leachate forming. The hot climate makes frequent turning necessary, and thus the risk of greenhouse gas emissions is low.

Social Policy Fulfilment

The compost site employs five black men. The former site manager has resigned and now the work at the sites in practice managed by the workers, even though a white administrator at the municipality is the formal manager. The municipality aims to put out a tender for running the compost as a co-op.
Since three of the workers have been employed since Reliance was in charge of the site, they have informal training on how to manage the compost. There is a small shed on the site available for the staff. The site has running water and the level of manual work is reasonable.

Future

There are ambitions for expanding the compost project, but this has to wait until the other parts of the Integrated Waste Management Plan are in place.

3.4 Makana Municipality

Grahamstown is the main town of the Makana Municipality which has 75,000 inhabitants. There are no major industries, but Grahamstown is an educational centre with a large university.

Situation of Waste Disposal

Illegal dumping and littering has been identified as a problem throughout Makana Municipality's urban areas. The occurrence of illegal dumping is especially prominent in areas characterised by high poverty levels and minimal refuse collection. In its waste management plan the municipality also aims to implement recycling, due to the potential to reduce transports and to lengthen the lifespan of the landfill sites.

Waste is collected door-to-door and via skips for garden waste that are put out in the streets. Many garden skips are in poor state, rusted and with large holes and are by the public used for general waste, much because there are no skips for domestic waste provided. Every year 40,000 tons of green waste is put on the Grahamstown landfill.[119]

Organisation and Financing of Compost Project

Concerned individuals in the municipality, coming both from an academic and from a community background, initiated the compost project. The municipality has given the project elementary support by providing land and some basic equipment. With the help of the Rhodes University's Centre for Entrepreneurship the project has been granted funding from the project Fresh Footprints of Carl and Emily Fuchs, which promotes projects that focus on social entrepreneurship and economic empowerment.

3.4.1 Mzam' Omhle Project

The ideas of starting a community project aiming at both waste management and income generation first came up in informal discussions between a university student working as a consultant at a brick manufacturer and a foreman working at the same place. The idea developed into plans for a compost project when the student contacted the Centre for Entrepreneurship and the economic viability was investigated. In 2004 the project was granted funding from a foundation and the compost project was set up as a co-op. It took three months to get the project going, and during this time the student was paid to learn about composting in practice. Since then another external person has been employed for three months to manage the project and this has had good effect. Now there is no external manager but a group member managing the site. The former managers still help out on an idealistic basis.

Type and Collection of Waste

The site is situated a few kilometres outside Grahamstown close to the landfill. There is an agreement with the municipality that the trucks that are used for green waste should discharge their load at the compost site instead of the landfill site, but this is not fully working at present, partly due to irregular opening hours of the compost site, and partly because many of the skips are too contaminated by other wastes. Except for the waste collected by the municipality, homeowners and garden companies also drop their green waste for free at the site. It is estimated that the compost site receives about 4,000 m^3 of compost every year. Only garden waste is treated and the waste is chipped with a small chipper.

Process

The chipped material is stored until enough waste has been received to form a new pile. Chipped green waste is mixed with grass clippings. The piles are about one meter high and are watered and turned manually about every second week. A anaerobically grown booster called Effective Microbes (EM) is purchased and mended in the compost.

During the process the temperature is measured and if it rises too high the pile is opened and watered. In the winter it can be hard to reach sufficient temperature, probably because the piles are too small to be self isolative.

High demand for compost causes selling of pre-mature compost after four to six months, although the group would like to keep it for nine months, with the last months

[119] Makana Municipality (2004)

spent under plastic in order to kill off weed seeds. Before selling, the compost is screened by shovelling it through a riddle constructed by an old bed bottom.

End Product and Market Issues

The compost is mostly sold in bulk and on order. There is a big demand for the compost and the project has some regular customers e.g. the university and gardening companies. No laboratory analyses have been done on the compost, but the customers are satisfied with the quality. The price per cubic metre is R660 in bag and R70 in bulk[120]. Some trials with selling bagged compost at the roadside have been successful but are time consuming.

Environmental Impact and Location

When applying for a permit for the compost site, an exemption from doing a full EIA and a public participation process was received. Still the process required much work. The project was however allowed to start before the permit was in place, thanks to goodwill from the municipality. To get the permit the project had to comply with the demand that the run-off water should be collected and recirculated to the compost. This is done by a ditch surrounding the site, but the surface at the site is not evened and there is seldom any run-off water to collect.

Figure 10 Part of the compost site at the outskirts of Grahamstown.

Social Policy Fulfilment

The project started with the outspoken aim of creating jobs and income for the community group operating the site. The enterprise is still dependant on external funding to buy equipment, fuel and maintenance for the machines, but the salaries for the six employees are covered by the incomes from sales. The Centre for Entrepreneurship, that has been advisory in the process of setting up the enterprise,

[120] In theory the price is 120 R/m^3, but there is no equipment for measuring the volume. In practice bucky load is charged R150 and have the volume of 2-2,5 m^3

recommended a smaller co-op in order to increase the chance of the project being able to supply the workers with a salary over the minimum wage of R45 per day. The group preferred to accept a lower income in order to spread the income among more members of the community.

Apart from creating jobs and income for the members, there has been skill enhancing training in composting and basic business skills, organized and in part supplied by the university. There has also been an informal transfer of organisational thinking from the external persons (Centre for Entrepreneurship and the former managers) to the new manager resulting in a change in the principles governing the division of work in the group. Instead of sharing all income equally, it will be divided more depending on the amount of work done.

Future

Funding for new equipment makes it possible to expand the project. The most crucial point is to develop the business skills and increase the productivity to make the project self-sustainable. The close contact with persons educated and devoted to the area of biological treatment gives lots of opportunities for experimenting on new composting methods and ideas.

3.5 Sol Plaatje Municipality

Sol Plaatje, formerly known as Kimberley Municipality, has 201,000 inhabitants. It is situated in the Province of Northern Cape in the inner parts of South Africa. The climate around Kimberley is essentially a continental one, the weather provides hot summers and mild dry winters. The annual average rainfall is 420 millimetres and most of the rain falls during the hot summer months. The infrequent summer rains tend to take the form of occasional severe thunderstorms rather than prolonged soft showers. It is not unusual for temperatures to drop below freezing in winter nights.

Situation of Waste Disposal

With a remaining lifespan of 10-15 years on the existing landfill, the situation is not deemed acute. The costs of establishing new landfills are, however, enough to motivate the Municipality to save landfill space by activities like composting.

Organisation and Financing of Compost Project

The first initiative in composting was taken by an entrepreneur, offering to start up a compost facility. The municipality liked the idea, but found the offer too expensive and therefore started to chip and compost waste from a vegetable market themselves. The project was turned into a co-op of persons formerly employed by the municipality and was funded by money from the Local Economic Development (LED) fund. The project experienced problems in getting the compost to work and after six months the project was temporarily taken under municipal supervision again.

3.5.1 Galashewe Compost Project

Type and Collection of Waste

The project treats green waste that is dropped for free at the site by homeowners and garden companies. There is no fee in leaving the waste to the landfill, but since the compost site is located closer to the living areas, there is an incentive to bring it there. Approximately 1,200 m^3 of compost is produced per year.

Process

After chipping the waste is formed into small windrows that are watered and turned with a tractor pulled straddle turner. The temperature is measured daily, and in summer the windrows are turned almost daily to prevent the temperature to rise too high. In theory a drop in the temperature is the criteria for considering the compost finished, but in practice the compost is sifted and sold after 6 weeks regardless of temperature. The sifting is done manually, but the workers have themselves constructed a sift, a horizontal net hanging like a cradle. The compost has to be shovelled onto the net manually, which is heavy work.

Figure 11 Straddle turner used at the site of the Galashewe Compost Project

End Product and Market Issues

The compost is sold on the site to homeowners, and even though the only marketing that has been done is a few adverts, there is a good demand. It is marked as soil enhancing medium, rather than fertilizer.

Environmental Impact

The site has no formal permit from Department of Water Affairs and Forestry (DWAF) and no EIA has been done. The surface is not graded and the run off water is not collected. Since the compost is turned so often, it is not likely that green house gases are produced.

Social Policy Fulfilment

The compost is operated by a group of black men and women. There has been no formal tendering process, but the workers have been chosen out of former experience in municipal work. The aim is that the project will turn into an independent co-op, but the supervising institutions deem that the group still need to be supervised by the municipality. However, the day-to-day work at the site is managed by the group themselves. The workers are all unskilled or semiskilled but have got informal training in running machines and making compost. The working conditions are relatively good, with indoor facilities and relatively low degree of manual work.

Future

The project has been granted 3,2 million to be used in upgrading the equipment during the coming three years, and the project will therefore upscale. The aim is to re-establish the project as a co-o.

3.6 Compiled results in tabular form

The empirical observations from all projects are compiled in tables 3 and 4 below.

Table 3 Summary of the visited compost projects

	Earth to Earth	Reliance	Pikitup	Radnor/Belville	Robertson	Kimberley	Grahamstown
Form of organisation	Private contractor	Private contractor	Municipal Waste Company	Municipal	Municipal	Municipal[1]	Cooperative
Type of waste	Green waste	Green waste	Green waste	Mixed household waste	Green waste	Green waste	Green waste
Collection	2 drop off sites	3 drop off sites and direct on site	5 drop off facilities	Curb side	Directly on the site	Directly on the site	Directly on the site
Waste treated (unchipped, m3/yr)	*288 000*	528 000	95 000		*36 000*	*19 200*	4 000
Waste treated (tons/yr)	*57 600*	*105 600*	19 000	31 200	7 200	*3 840*	*800*
Compost produced (m3/yr)	54 000	66 000	12 160		*1 920*	1 200	500
Compost produced (tons/yr)	*33 750*	*41 250*	7 600	28 500	1 200	*750*	*300*
Number of employees (excl drop off site and administration)	5	~16 (estimated)	16	37	5	14	6
External funding/subsidiaries	No	No	Yes	Yes	No	Yes	Yes
Main market	Landscapers	Landscapers, Organic farmers, Nurseries	Homeowners	Municipal use	Homeowners	Home owners, garden companies	Garden companies, university, homeowners

Table 4 Description of the project's process and product control

	Earth to Earth	Reliance	Pikitup	Radnor/Belville	Robertson	Kimberley	Grahamstown
Preprocessing	Chipping	Chipping	Chipping	Hammer mill, magnet and manual sorting	Watering, chipping	Chipping	Chipping
Type of process	Turned windrows (large)	Turned windrows (small)	Turned windrows (large and small)	Fermentation drum, turned windrows (large)	Turned windrows (small)	Turned windrows (small)	Turned windrows (small)
Turning equipment	Front end loader	Straddle turner	Straddle turner	Straddle turner	Straddle turner	Straddle turner	Manual turning
Process time (weeks)	10-13	6-8	14-16	16-24	8	6	24-36
Sifting	None	Machine	Machine	Machine	Machine	Manual	Manual
Additives	Urea and/or fertilizer (150 kg/500m^3)	Inoculums	None	None	Manure (2 kg /m^3) or blood	None	Sawdust, inoculums
Process control parameters measured	Temperature (occasionally) pH (occasionally)	Temperature, CO_2 levels (regularly)	Temperature (regularly)	None	Temperature (regularly)	Temperature (regularly)	Temperature (regularly)
Test for maturity	None	Temperature and labtests	Temperature	None	None	Temperature	None

4 Discussion

4.1 Technological Process

Technology used

All projects used the well established method of composting, turned windrows. The main difference between the projects was the turning mode and the size of the windrows. Large windrows of more than about 1.8 meter, called Trapezoids, were said to have the advantages of being more space efficient and less prone to dry out than small windrows. Since they did not need to be watered as often as small windrows, they were turned less frequently. Both literature[121] and persons working in the projects stated that mechanical turning was important for the break down of big and woody peaces in the compost, and that intense turning made the process faster. Therefore, the compost from Trapezoids contained larger pieces and blobs that was not decomposed and it took longer until it reached a stable state. However, in practice the projects interrupted the compost process before the temperature went down to ambient and sifted the compost so that the large pieces could be reused and further decomposed in a new windrow, while the fine fraction was sold. Since these pieces contained the right micro fauna for the compost, they should in practice function as inoculum.

The advantage of small windrows was, according to the interviews, that they were more easily manoeuvred and thereby did not require as expensive equipment. The disadvantage was that they were more sensible to weather conditions. In the hot season they dry out more easily and therefore needed to be turned and watered more frequently which demands more work, but also contributes to a faster process with less anaerobic patches. In winter it can be hard to get a high temperature in these windrows.

During the peak season in summer, when the projects were visited, many of the projects had stacks of unprocessed material on the site. In some cases the reason for this was lack of space to form new windrows. Other projects had problems with machinery breakdowns and could not chip the material at the necessary rate. This unprocessed material took up space at the site and caused a high risk of fire, especially during the hot season. Based on the theory presented in chapter three, it is also likely that the nutrient level in the finished compost will be lowered if the material is let to dry out. The seasonal changes in incoming material are thus also needed to be taken into consideration when planning and constructing a site.

Source Separation of Waste

Literature[122] show that clean incoming material is a foundation for a well-functioning process. All of the projects were aware of this and made efforts to secure the standard of the incoming waste. The incoming waste in all of the projects, except for the project treating mixed household waste, was relatively clean.

The source separated waste was received in two different ways, either direct at the compost site, or at separate drop offs. The advantage of having separate drop offs is that

[121] Manser & Keeling (1996) p. 178
[122] Diaz (2003), p. 178.

waste can be collected from a larger area, but with the disposal site still at convenient distance for the households. If the waste is chipped at the drop of site, transportation is minimised.

The larger projects collected their green waste from drop off sites which dealt with a variety of waste. All of these projects had some problems with contamination of other materials in the organic fraction, such as plastic bags which were often blown by the wind in to the material from the nearby containers. The smaller projects had less problems as only green waste was allowed on their sites. These projects had on the other hand been forced to put up fencing in order to avoid illegal dumping of other waste during nights and weekends. A common problem was contamination of gravel and dust from the sites, since the surfaces were not paved.

All projects had site managers to make sure that only pure green waste was received. Our conclusions is that it was of big importance that the managers were responsible and motivated to secure a high standard of separation and cleanness of the site. It is probably easier to get this motivation when the waste is received directly at the compost site by the same persons managing the compost.

One municipality that had separate drop of sites had noted a big improvement in the maintenance of the drop off sites since they were taken over by a private contractor. Experiences from a similar project shows that municipally owned projects also can be successful in motivating their personnel. In this case it was achieved by internal training of the drop off site managers and feed back on the quality of the separation from the manager at the compost site.

A good separation of the waste is not only important to get a pure incoming material, but also in order to maximise the amount of waste that is diverted from landfills. However as much as one third of the green waste received at the drop off sites went to landfill since it was so contaminated that it was not worth the effort to sort out the green waste. Thus, all the visited projects had the possibility to further reduce the amounts of waste going to landfill if public awareness can be increased and sufficient source separation can be encouraged. In the projects this was done by school campaigns, and leaflets.

Inoculums

Some of the projects used inoculums called Effective Microorganisms to boost the composting process. This inoculum is a liquid concentration of bacteria added to the compost in the initial state in order to get a faster initial decomposition rate. Some kinds of inoculums are produced and used for composting a particular type of waste. One of the projects was themselves producing and selling inoculums and another had started to use it after stumbling upon the method. In other projects blood or manure was used as a ”booster” for the process, while still others said that there was already enough micro organisms in the waste to get the process started. A brief search on the Internet shows that the use of Effective Microorganisms is internationally spread, not only for composting but also for farming, animal husbandry, sewage treatment, hygiene management, and environmental regeneration[123]. The effect of this technology has been questioned[124], and we can not say whether it is advisable or not.

[123] AuroAnnam (2006-05-31)
[124] Acevedo et. al (2005) Diaz (2003) p. 129

Process Knowledge and Process Control

The background knowledge on composting varied very much between the projects, as did the way that new knowledge was obtained. In the region around Cape Town the farming industry had generated a base of both practical and academic knowledge, that was of great use and importance to the projects there. Also in Durban, another major city in South Africa, there was a strong linkage between academic research and practical waste treatment, but here the municipal compost project was still in its planning phase[125]. Most of the other projects had started from scratch with no beforehand knowledge on composting, but learned underhand.

Several projects referred to the CMC (Controlled Microbial Composting and Humus Management) method developed by the Lubke Family in Austria. The CMC Compost Consulting group have also given courses in composting in Stellenbosch which some of the projects had visited. This might be the reason why most of the projects used a similar technology. Other ways to obtain practical and formal knowledge on composting included looking at relevant Web pages and articles published on the Internet and knowledge exchange with local farmers. The choice of information sources depends on contacts and knowledge on how to find material and courses that suite economical and personnel structures of the project.

The most common parameter measured in the projects was temperature. This was used to decide when to turn the compost. In the summer, the hot and sunny weather of many areas in South Africa caused the temperature to rise too much in the windrows, causing the compost to "burn". To avoid this the turning frequency in practice was determined by the need to let the heat out, and was thus done when temperature increased above 65 – 70° C. Temperature was in theory also used to deem the readiness of the compost, but in practice standard times was used and the compost process in some cases was interrupted before it was stable.

In summer, the climate promoted a fast process, and the main problem was to keep the windrows moist, especially in the dry areas around Cape Town. Advanced process knowledge did not seem necessary. Instead the practical ability to turn and monitor the process was the limiting factor. The machinery being used differed much in scale and standard, and some of the projects were under-equipped. The most advanced and efficient composting machinery were produced abroad and made it possible to monitor the process well. The disadvantage of using these machines was that repairs were costly and it took long time to get spare parts. The interruption in process control and treatment caused by machine breakdowns was a problem mentioned by all composting projects.

In winter composting seemed more problematic, and the risk of getting a disruptive behaviour and a immature compost product was higher. One of the projects had great knowledge of the biochemical properties and the microbial activities in the compost. In this project the compost was tested for readiness in a laboratory. Even if we do not know if the testings contributed to a higher quality or less problems than in the other projects, the testings were a guarantee that no phototoxic compost was sold and the company had a reputation for producing high quality compost. Therefore we think that

[125] At the time for the visit the Park Division in Durban Metro had a small compost facility for green waste, but so far it only functioned as pre treatment for landfilling. There were plans for starting a compost project, but since these were not yet realised we did not include the project in the study.

greater knowledge of the process was important to have a high and reliable quality on the product.

End Product

All projects were more or less able to turn the green waste into a soil-resembling product, but in some projects most of the compost was sold unsifted and rough. There were indications that the quality of the product varied much between different projects, with the lowest quality in the municipal project treating mixed household waste. This compost was by one interviewee described as "a heap of rubbish". Our conclusion is that this was due to lack of monitoring of the process, especially regarding the poor quality of the incoming material.

A careful evaluation of the quality of the compost product can only be done with chemical analyses. Only two of the projects could give us prints on laboratory tests done on the final product. These are shown in Table 5. As a comparison, the values of a compost produced from chicken manure is shown. The tests show that although the composts made from green waste are lower in macro nutrients than compost made from manure, as could be expected, they contain valuable nutrients. The levels of harmful heavy metals were not measured except for copper, and it was stated that the reason for this was that it was neither required by law nor by the municipalities.

Table 5 Chemical analyses on the end product from three different projects

	Compost from municipal green waste, municipally driven project	**Compost from municipal green waste, private contractor**	**Eco certified compost made of chicken litter**	
N	1.25	1.11	3.6	%
P	0.23	0.17	1.2	%
K	0.73	0.76	1.3	%
Ca	2.29	0.61	1.8	%
Mg	0.39	0.14	0.5	%
S	0.2		0.6	%
Na	414	1464		mg/kg
Cu	53	6.2	20	mg/kg
Fe	27900		1000	mg/kg
Mn	464	57.92	320	mg/kg
Mb			4	mg/kg
Zn	132	76.78	215	mg/kg
B		8.59	40	mg/kg

Even though the quality varied, all projects were able to sell their compost. Compost can be used for many different applications and the customers varied from organic farmers and landscapers to homeowners and municipal infrastructure projects.

Compost that is to be sold as fertilizer should be registered as a “Group II fertilizer” by the Department of Agriculture. To get the registration it is required that a chemical analysis of the compost is done. To avoid the costs of laboratory tests and for registration many projects avoided marketing the compost as fertilizer, but instead called it "soil enhancer" or "growing media". The lack of tests of these products was something that the producers of the higher quality product were very disturbed by, since it was harder for them to prove that their product was better and worth a higher price. We think that all projects should be better in specifying the quality of their end product, for example regarding organic matter content, moisture content, salinity and the content of possibly harmful metals. This information would be valuable both for market reasons, for a better control of environmental impact and for the producers themselves in their work to refine the process.

Figure 12 The quality differs between projects. In some projects it is rought (left), and in others tests is done to deem readyness (right)

4.2 Environmental Sustainability

The legislation in South Africa is ambitious, demanding that an Environmental Impact Assessment (EIA) is done before giving a permit for a new waste treatment site. In the case of composting garden waste, an exemption is normally given, reducing the demands of the full EIA. Still the EIA process was seen as very difficult and time consuming by all the projects.

It was evident that the regulation was not enforced everywhere, and it seems to be applied differently in different places, probably because the laws in the area were still new. One project met demands on run off water to be collected and recirculated, while others had taken no measures to lessen the environmental impact. Many of the projects run on the permit of a former plant on the same site without upgrading it to the new conditions and regulations.

The general view in the projects was that the environmental impact of green waste composting is negligible in comparison with other ways of treating waste, such as landfilling. As long as the projects are small scale and treat only garden waste this is true, especially during the dry season. However, many of the projects plan to upscale and change to more problematic wastes, such as sewage sludge and abattoir waste and therefore the question should not be neglected. Since the main environmental impact of composting is contamination of ground and surface water, as stated in paragraph 3, a minimum demand is therefore that the leachate should be collected and recirculated to a compost heap which has not yet been sanitised.

Some projects used big windrows, more than 1,8 meters high. Even if there are many advantages with this approach, it has the disadvantage of increasing the risk of anaerobic conditions in the heap resulting in emissions of green house gases. This was especially so when constraints in space, human or technical resources makes the turning insufficient. Big windrows should therefore only be used in projects which have the capacity to manage them well.

Road-side clippings or garden waste might contain residues of toxic organic substances originating from biocides and traffic pollutants. However, none of the interviewed persons were concerned about what toxic substances there might be in the waste. Green waste is at this stage considered unproblematic. This is especially problematic in the projects where mixed household waste is treated, since this end product in all likelihood is very contaminated. A few projects have considerations about possible low content of organic matter in the compost, because of dust and dirt contaminating the compost, but this is not measured in any project.

4.3 Economic Sustainability

Initial Funding

All of the municipal projects had started with help from external funding. The most common source is governmental funds for municipal investments in infrastructure, which can contribute with up to 70 percent of the investment costs for equipment, or funds for local development. In one case the support was not only economic, but also consisted of long term aid of a consultant based in another country. The project considered this to be very valuable. Other sources are international aid and national private funds.

Investment costs

In our case studies the costs for setting up and equipping the composting site ranged between R200,000 and R14 million depending on the scale and ambitions of the project. To this the costs for external drop off sites was added. In most cases the municipality supplied the project with land and water, thus reducing the costs. The location of the site is important from an economical point of view, due to the cost of transport. On one hand it is important that the site is located within a distance accepted by the households. Otherwise insufficient amounts of waste come to the site and the risk of illegal dumping is enhanced. The benefits from having the site closely located to the producers of the green waste, often high income areas, must however be weighed to the importance of having the site close to low income areas since most of the workers live there. The workers at one of the visited projects did not have the economic means to go by bus to work. They walked a long distance which affected the time and energy spent at the work, and thus the efficiency and the economic sustainability of the project. If the goal is to support the entrance of previously disadvantaged people into the economy, even the practical possibility to participate must be improved.

Regardless of the scale[126] of the project, the costs for equipment and machinery requires considerable investments in relation to the available economical resources. The larger the project, the more expensive the equipment is required. On the other hand, even very small scale projects need some machines. The visited projects that had small financial resources had found different solutions to this problem. Some of the projects had bought

[126] When comparing our study objects we saw that they fell in to two categories, with three producing less than 2,000 m^3 and four producing more than 12,000 m^3. We used this gap to define the former as "small scale" and the later as "large scale" projects.

second-hand equipment, and recommended it. The price of a second hand turner was between 30-80 percent of the price for a new machine[127], depending on the condition. In two of the small projects costs on machinery was saved by substituting machines with manual labour, using home made equipment. Some tasks done manually were sifting and sometimes turning. Other tasks, as for instance the chipping of the waste, is too difficult to do manually and machinery is necessary. The chipping machine was one of the most expensive machines needed in the projects. One of the projects had a large chipper which cost R600,000, a medium chipper cost about R120,000. It is exposed to a lot of wear and tear and is therefore not bought second hand. Machinery breakdown is a major problem since it caused high repair costs and unwanted process interruptions. To prevent this the projects tried to sort out hard wood, as Acacia, and large pieces of wood from the waste. One of the projects watered the waste before chipping, in order to soften it.

Even in large scale projects factors as the short municipal tender period makes it impossible to invest in machines and so some of the machinery has to be rented from a company with better means for investment.

Figure 13 Examples of sifting, done mechanically in a large scale project and manually in a small scale project

Operational costs

Our calculations[128] suggest that the treatment costs per cubic meter of (unchipped) green waste was in the interval of R16-R25. Since it took about 8 m^3 of unchipped waste to produce one cubic metre of compost, the production cost per cubic metre of compost was R130-R200. It was hard to tell if the cost per cubic metre was higher or lower in large than small scale projects, since the large scale project we visited had not yet reached the volumes intended when investing in machines.

In the case where the municipality used a private contractor to treat and collect the green waste, they paid about R30 per cubic metre of chipped green waste. That came down to R7.50 per cubic metre of unchipped green waste, or R60 per cubic metre of compost.

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[127] The price of the turners varied, depending on if they were self powered or not, between R100,000 and R300,000

[128] The data on costs, incomes and volumes in the projects has in some cases been imprecise. These calculations is therefore only intended to indicate the approximate levels.

Marketing and Sales

The general experience in the projects was that the compost was easy to sell. There was a large demand for compost and growing media from homeowners, gardeners and landscapers. The projects differed in how much effort and finance they put into marketing, with some projects doing no marketing at all. One of the economically most successful projects put big efforts in marketing and creation of goodwill, spending 4 percent of the total expenditures on marketing per year. It is probably so that with growing volumes to sell and with more competition, marketing will pay a more crucial role. Positive branding and goodwill creation among citizens and politicians not only facilitated the selling, but also facilitates the collection and separation of waste and the localisation of sites.

The most common way of selling the compost was by bulk directly on site. This alternative forced the projects to take a low price but rendered savings in costs for bagging and distribution. Some of the projects mentioned the difficulties in reaching the market through retailers in form of nurseries. This puts demands on bagging and reliable distribution. Another obstacle was that nurseries often required a range of products to present to their customers and therefore were not interested if the project could only supply one type of product. A few of the projects had reached a stage where they did have a good product and were trying to expand their business to be able to compete with private composting companies supplying nurseries. The question of marketing was of course also a question of finance. One of the small projects with very meagre means for marketing sold their product along the street and handed out flyers. It worked quite well but took a lot of time.
The prices varied between the projects something that not only was dependant on the quality of the product. Compost was sold in bulk for R70-R150 per cubic metre and in bag for R200-R660 per cubic metre.

Self-Sustainability of the Projects

Composting is not only a way of treating waste, but also production of a useful product that generates income when sold. When the municipality does the composting themselves, they therefore have the possibility of covering all, or parts of the costs by selling the compost. Our calculations, based on the volumes and prices of compost and the operational costs, suggest that when sold in bag, the compost gave incomes that covered the production costs, but not when sold in bulk since it then rendered a lower price. Since most of the compost was sold in bulk, it was sold at a loss. It is however important to emphasise that most of the projects were still in the starting phase and because of this also might have had higher costs per produced cubic meter of compost than will be the case in a few years time. Two of the projects has good prospects to break even within a short future.

In Table 6 the total loss generated per cubic metre of unchipped waste is shown. In the first column the theoretical case where all compost is sold in bag is shown. The calculation is based on treatment costs and prices per cubic metre of compost. In the second column a more accurate case, with most of the compost sold in bulk, is shown. When calculating this figure we used the total operation costs minus the total incomes from sales and divided with the amounts of waste treated. The conclusion is that the projects today are dependent on an external funding of R5-R10 per cubic metre of unchipped green waste taken care of. This can be seen as the net treatment cost that the municipality has.[129]

Table 6 Total cost per cubic metre of green waste

	Sales in bag	**Actual mix of bag and bulk**
Net treatment costs / m^3 unchipped green waste	- R10 to -R35 [1]	R5 to R10

[1] Note that this is a negative cost, that is a profit per m^3 of sold compost

Economic Viability and Organisation

When discussing the economic viability of compost projects we noted a difference in the mindset depending on the organisational form of the project. In the case of private-public partnerships it seemed fully accepted that the municipality had to pay their contractor for the service of treating the waste. Municipally driven projects and co-ops did not have this additional income since they accepted waste free of charge. Still they suffered under the (sometimes unspoken) demand to break even. Our calculations above show that, when taking the incomes from sold compost into account, the operational costs for the municipality is within the same range (R5-R10) regardless if they use a private contractor, a co-op or do it themselves. [130] This indicates that other factors than operational costs should be decisive when choosing organisational form.

Since municipally driven projects and co-operatives often put more effort in fulfilling social policy goals, this type of organisation thus gave benefits to the municipality in many ways but also put more demands on the municipality in form of knowledge and supplying training to the members of the cooperative. The private companies on the other hand were often more productive than the cooperatives and often have more resources to spend on research and development of the process. This is something that can be a contribution in future work for enhancing the national level of knowledge in composting. There is therefore no optimal choice for a municipality in choosing between a private and cooperative solution. It is up to each municipality to look at the different options and weigh them against one another.

Alternative Costs

All of the visited municipalities, expressed that the compost projects generated savings compared to alternative treatments of the waste. By calculating the alternative costs, a project that is not economically sustainable in private ownership can be sustainable from the municipal point of view. In one of the studied cases the municipalities realized this and thereby took over the site themselves when the project was not economically profitable in private ownership.

The municipalities in this study differed very much in what economic requirements they had on the compost project. Some had put effort in trying to calculate the alternative

[129] In the calculations we have assumed that eight cubic metre of unchipped waste corresponds to 2 cubic metres of chipped waste that is further reduced to one cubic metre of compost. It is important to take this volume reduction into account when comparing costs of alternative waste treatments.
[130] The municipality pays about R30/m^3 for chipped green waste taken of the drop off site by a private contractor. This corresponds to a cost of R7,50/m^3 of unchipped green waste.

costs and thus get a picture of how much the project could cost in order to still be economically sustainable as a whole for the municipality. Other municipalities were aware of the benefits and savings but refused to take this into the economical calculations and required that the composting projects should break even, without taking this into account.

Even if the municipalities were calculating with alternative costs the calculations looked different. It is difficult to define what costs should be taken into account. Some costs, for instance the savings in transport, could quite easily be analysed and calculated and are often included. To make a fair comparison between landfill and compost not only operational costs, but also capital costs should be taken into account. When this is done, the total cost for space in the landfill is much higher than if only operational costs are taken into account. This is because landfills are very expensive to set up and to close down, and have a limited capacity. Even if many municipalities are aware of this, it is seldom included since the capital costs are hard to estimate. Other values that are hard to put a price on is the long term benefits of a clean and safe environment for the citizens, the fulfilment of social policy goals and public goodwill creation.

There are thus infinite ways to calculate the alternative costs. Only one of the municipalities was able to give us estimated costs of landfill space, which was R146 per cubic metre of compacted waste. Since we could not get any explicit information on how this cost for landfill space was calculated, we consider this an important factor to investigate further. However, it is evident that even without knowing the actual costs, the visited municipalities see recycling of green waste as a good way to prolong the lifetimes of the landfills and to make financial and environmental savings.

4.4 Social Policies

Employment Equity and Management Control

All of the projects in the study were affected by the social policies of Broad Based Black Economic Empowerment since these were set by law for municipal enterprises and their partners. We did not receive detailed information on the BEE scorecard from any of the projects. The reasons for this was either that the company lacked a BEE scorecard or that the enterprise had a scorecard, but that it was not a part of the regular day-to-day work, but something that was done in connection with tender processes.

We identified two main strategies taken to comply with the regulated BEE standards. One was by formal transactions, such as giving away or selling parts of the company or by forming a joint venture with a company, for example a transport company, which had a high BEE score. Hereby the company could keep their traditional internal structure with non-whites as manual workers and whites, or sometimes coloured, working as managers and in administration. The other strategy was to form a co-op that was run by Historically Disadvantaged People (HDPs) only. The strategy chosen depended on the organizational form of the project. Private-Public Partnerships tend to involve companies that used the former strategy, while municipally driven projects favoured the later. The alternative of making substantial changes in an existing enterprise with the traditional hierarchy between whites and non-whites was more rare. Only in one case was this observed. This was a case of a municipally owned company that made, what seemed, serious and rather successful attempts to change the traditional structure.

Our conclusion was that projects with a high involvement by the municipality were better at addressing the BEE goals of employment equity and management control. This was especially true in the case of the co-ops. Even if the private firms, using the strategy of preferential procurement and joint ventures, were in general not as successful in changing the structure within the company this strategy might create a market for companies owned by HDPs "down the line". A weakness in these strategies was that it only had limited impact in changing the segregation of different groups in the society, creating a situation where established enterprises kept their unequal structure and enterprises owned and managed by black people were new and small scale.

The policy of BEE is not only targeting black persons, other Historically Disadvantaged People, including women and disabled are also included in this category. All projects were low in female workers and managers although there were a few women working as site managers at drop off sites. The reason stated was that the work was to heavy and traditionally male dominated to attract women. At a visit to a large private company treating industrial waste 60 percent of the permanent staff was female, and 80 percent of the managers were female. The attitude here was instead that women often worked harder than the men. This is an example which shows that private companies also can make substantial contributions to the fulfilment of the goals of BEE.

Attitudes

The inequalities between different groups are not only evident in formal structures, but also in the behaviour and attitudes among the groups. Here we conclude that there was a notable difference in attitude at the workplace between co-ops and traditional private companies. This conclusion was in large based on the experience gained at companies that are located in an area dominated by wine farms. It might be the case that the local history and the heritage from this industry affected the companies more than in other parts of the country, since traditional structures were still strong in the wine industry [131]. It was only at the co-ops or municipally owned sites that the workers on the site were encouraged to talk to us, and could explain their work and the process. The longer the site had been run by the workers themselves, the more did they give the impression of really being in charge and responsible for the enterprise.

Still, the actual division of work tasks and responsibilities are not so different in co-ops from other projects. None of the co-ops that we visited were yet running totally independently but received supervision and support from the municipality or other institutions. Even though there were no formal leadership of the white officials in these institutions, it was evident that old structures still affected the roles the parties took to each other. It is put of the scope of this study to tell how much of this that is due to skin-colour,other social hierarchies, and how much that is due to lingering differences in skills in knowledge. Our conclusion is however that regarding racial inequalities, it is harder to change patterns of thought and behaviour than formal structures.

Skill Enhancing and Training

Almost all projects respond that they are giving, or intend to give, the workers "training". It is evident that "training" is not only referring to formal education and skill enhancement. At many sites "training" just means that the manager instructs the

[131] Ewert & Hamman (1999)

workers how to perform relatively simple tasks, such as moving compost heaps. Informal training can be valuable, helping staff to develop new skills by learning from others.

When formal training took place a difference was seen in who got which type of education. The workers on site receive either basic school education, courses in basic business skills or courses in work place safety. Advanced training in composting was, in our observation, exclusively for managers or other persons in lead positions and consequently only given to whites. In the case of co-ops the persons sent to the composting course were not directly involved in the work at the sites, creating a situation where an external supervisor has the formal knowledge and the persons working with the process develop a practical hands-on knowledge. In the case where a municipality wants to start many small scale compost projects it can be seen as a resource efficient solution to educate one or two key persons that in turn can supply all projects with knowledge. This can however create a vulnerable situation, more than one of the projects had suffered from loosing key persons and thereby important knowledge.

We observed that the lack of formal knowledge on the composting process created misunderstandings that might lead to a suboptimal monitoring of the process, for example when microorganisms are confused with invertebrates. Another drawback with this strategy is that it might lead to frustration when highly motivated managers and workers do not feel that they have the opportunity to develop their formal knowledge but are dependent on others, outside the project, for knowledge and assistance.

Job Creation and Working Conditions

The projects employ between 5 and 26 persons, with 5-10 persons involved in the actual composting and with the others engaged in collection, sorting and chipping of waste. This figure was highly dependent on seasonal variations in activity. In order to reach sufficient volumes, large scale projects required special personnel working at internal or external drop off sites making sure that as much waste as possible is sorted out for composting.

The policy for job creation and poverty alleviation was well spread and accepted and all projects were motivated to contribute to the fulfilment of this policy. The fact that labour was extremely cheap, whereas especially foreign technology is expensive, could be a contributory cause to this. In many cases it was a lack of economical resources rather than the job creation policy that dictated the level of mechanisation. Two of the projects had had the resources to go for a more technology intensive practice with larger machines.

The literature often recommends that composting projects should opt for robust and low-tech technology[132], especially in developing countries. We would like to stress that this advice should not be interpreted as a recommendation to under dimension the equipment. In the case of green waste composting, even small scale projects need mechanical equipment for chipping the waste. If this is under-dimensioned and overused it will be worn out prematurely, causing high repair costs.

[132] Drechsel & Kunze (1999)

To focus too much on labour intensive practices might also worsen the work conditions for the staff. Some parts of composting, for example turning and sifting, are very heavy work if done manually. Working manually with the compost can be detrimental to the workers as bioaerosols and dust can cause health problems. This risk is enhanced in the cases where the staff and their families live on the site and thereby are constantly exposed to the dust. [133]

In one project we learned that the members of the co-op preferred to employ more people even if they had to accept lower wages. In the case of an independent and democratic co-op this is of course optional, and it might even be beneficial for the community to spread the income among more people. The policy of job creation is thus well spread, but we see the risk that the goal of creating as many jobs as possible might lead to compromises in work place safety and levels of payment.

[133] See chapter 3

5. Conclusions

In this chapter conclusions and recommendations for each area of evaluation is presented. Based on these, a discussion on the municipals options when deciding in scale and form of organisation is also given. Finally some recommendations for future studies are suggested.

5.1 Technological Process - To transform waste to a useful end product

Even if the throughput differed very much in different projects, all were able to convert the waste they received to a soil resembling product. The quality of the end product varies between the different projects, and it is especially low when the waste is not separated at source. Some of the projects are also producing very rough compost. Explanatory factors for these differences are type of incoming material, pre-treatment of the waste and level of process control. The process control is both affected by limitations in knowledge of the process, standard and breakage frequency of the machinery, what measurements are taken and how regularly. Also affecting the quality of the end product is the fact that most of the projects had incentives to sell the product before it had reached a mature state. All of the projects are, however, producing a product that has a market even if the end use of the product and the customers are ranging from padding in municipal projects to homeowners and organic farmers. We recommend that a better national certification system for compost should be developed in order to specify the quality difference on the market and thereby give the producers incentives to further develop the product.

It is important with a good source separation of the waste, both to get a good process, a high quality product and to reach sufficient volumes. Factors affecting this is public awareness and motivation among the staff working at the drop offs. If the persons responsible for the separation of the received waste are responsible for the whole composting process, a better result is reached. When this is not the case education and motivation for the staff at the drop of site is important.

A paved surface is recommended since it improves factors such as working condition, control of leachate and organic content but we are aware that this is very costly and that it therefore is not seen as an option for many of the composting projects.

5.2 Environmental Impact - To minimise and control negative environmental effects

The environmental impact of green waste composting is viewed as negligible by the operators. Together with insufficient enforcement of the environmental legislation, this results in a situation with few incentives to prevent environmental impacts. This neglect was so far not posing any major problems, but if the projects change to more problematic wastes and increase their throughput, the situation might change. With ambitious policies and legislation the government shows intent to improve the environmental situation and it is thus advisable to take these factors into account from the start. More measurements should be done to make sure that the end product does not contain harmful substances. The risk for this is especially high in the case when mixed household waste is treated, and therefore only source separated wastes should be treated.

5.3 Economic Sustainability- To achieve economic sustainability

At this stage none of the visited projects generate income from sales that cover the costs. This is partly because most of the projects have not been running for very long. Some projects, both private companies and one municipality see great potential in the business and are calculating that the projects soon will break even. Other municipality driven projects are calculating with the savings in costs for alternative treatment of the waste and either making overall savings already, or valuing the benefits in other areas such as environmental status, social policy fulfilment and job creation as high enough to make up for the costs of the project. When municipalities are calculating the economical viability of compost, the saved costs from alternative treatment of the waste should be taken into consideration in order to get a just picture of composting as an alternative to landfill. When it comes to improvements in the environmental status and other non-market values, estimation of the benefits in these areas must be made in order to promote sustainable development.

Regarding large scale projects, we also recommend that financial means should be allocated for process measurements and quality control in order to be able to produce a better product and to be prepared to deal with more complicated waste.

5.4 Social Policy Fulfilment - To contribute to social development

There is an over all high awareness of the importance to fulfil social policy goals. The strategies differ in different organisations, and the projects with municipal involvement seem to bee more ambitious. However, even in these projects, old structures and attitudes prevail to some degree despite formal changes. The effects of the changes seem to increase with time when skills and higher self-consciousness are developed among the HDPs. A key factor in the process is the transference of formal and informal knowledge and management responsibilities. If the main goal is to promote social policies, we therefore recommend the organisational form of co-ops.

5.5 Scale and organisation

When starting up a compost facility the municipality has two major factors to decide upon namely scale and organisational form. What the municipality chooses is both dependent on what goals the municipality has and, even more, on the resources available in the municipality. We here discuss three possible options presented to the municipality.

In the case where there is no former developed knowledge in composting in the municipality or in the private sector, it is natural to start in small scale. The advantage of running small scale compost facilities is that they do not need as large investments in machineries and formal education in composting. With motivation and a minimum of training, the people working with the project develop a hands-on-knowledge that is enough to treat the waste and produce compost. It is however important to stress that the costs and effort that small scale projects demand should not be neglected. All work is not suitable to do manually and therefore some machinery is needed. If the staff is unskilled, efforts in business training and other basic skills is also necessary. There should also be someone connected to the project that has formal knowledge in composting that can assist the project. To fight the former unequal structures the person that gets the formal training should be a HDP, and preferably someone working directly at the site. Because of the demands for minimum investments in small scale projects, it is not self evident that the cost per produced cubic metre of compost is lower than in large scale and more capital intense projects. On the contrary the study suggests that it is hard to get a small scale project self sustainable. The municipality should therefore either run the project themselves, or be prepared to give financial support to the project for at least some years if run by an external actor. This actor can either be a private contractor or a co-op. Since the co-ops in this study seemed better in fulfilling the social goals of skills development and poverty alleviation, this option is preferable, since the municipality then promotes more goals than waste treatment.

If there exists a base of compost-related knowledge in the industrial sector in the region, this can be utilized to start at large scale compost project in the form of a private-public partnership. Even if there is no established composting sector in the area, a municipal contract can give a private actor better opportunities to develop and learn the new technology.

The advantage of starting a private-public partnership is that it takes less effort from the municipality and that the costs for the municipality can be more predictable since there is a formal tender process. The conclusion in this study is however that the costs for the municipality are about the same regardless of the organisational form. Neither can it be proven that a private contractor produces a more high quality compost. However, they have strong incentives to make the project efficient and are large enough to be profitable. To make themselves less dependent on one contractor, the municipality can choose to invest in the infrastructure (the site and the equipment) and just lease them out to the private contractor for one tender period at a time. When closing this kind of contract experience show that the municipality should make sure to state the expected level of maintenance of the equipment.

The third option for the municipality is to start a large scale compost without forming a private-public partnership. Experiences in one of the visited project showed that this can be very successful. It should however be noted that this was done by a municipally owned company, that in some regards was more similar in their incentives to a private company than a municipal department. This option can be seen as a cross between the two options mentioned above. The advantage of this organisational form is that both the economical and social incentives are strong.

5.6 Future Studies

This study has been looking at the sustainability aspects of composting of municipal solid waste by evaluating the results from initiatives taken so far.

Since this is one of the first studies in this area, the focus of this evaluation has been to get a wide picture of composting of municipal waste in South Africa. In order to further understand the social and technological processes it is necessary to conduct more in-depth studies of each area. We hope that this initial effort can prove valuable for both further studies and people involved in municipal composting projects. Here are some suggestions for topics that deserve further investigation.

Technological process

Analyse the end products with regard to content of organic matter, toxic compounds and heavy metals, and the condition of the natural soils where the compost is spread. Based on this, quality guidelines for compost with different applications could be made. The result would be valuable in the work of setting up national certification criteria.

Environmental impact

Apart from only estimating the direct environmental impacts from the alternatives for waste treatment, an assessment from a lifecycle-perspective would be valuable from an environmental sustainability point of view. This should not only include the direct impacts, but also the more indirect, as emissions from machines and transport together with emissions that will arise in long time perspective.

Economic sustainability

A more careful evaluation on the cost and benefits from composting should be done in order to better compare it with other alternatives, as landfilling. One thing that we see as a weak point in the assessments that has been done this far, is that the conversion factors between raw waste, chipped waste, finished compost and waste that is compacted on a landfill are not clear. Today one cubic metre of waste is by default set to equal one ton, which might be true for compacted waste, but not for unchipped green waste. This is important to look further at in order to get true comparisons.

Social Policy Fulfilment

Another area that we find important to further look into is the long term effect of different types of training. Our study suggests that the actual BEE status is higher in co-ops than in other form of organisation. It would be interesting to understand if this result is true in general and, in that case, what parameters are affecting it.

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Eric Zinn, SWECO, personal comment, 2005-08

Ken Kendall, personal comment, meeting at NMMM, 2005-11-05

Appendix 1 : Topics of Investigation

Here are the areas and questions that we based our interviews on. Some of the questions were not asked in the interviews but are intended to be a reminder to us about what to observe at the site.

Organisational and Social Factors

-Background and development of the project?

-Process from idea to running project?

-What actors initiated the project and what actors are operating the project?

-What other actors have influence of the project? Is there cooperation with external actors as universities, NGO:s companies, other composting plants, or others?

-Future goals and plans?

-Do you plan to expand the project? Obstacles involved?

Technological Process

-Number of composting sites?

-Running scale of project (actual and possible)?

-Type of composting technique, including pre treatment, and after treatment?

-Have other techniques been tested? Why was this technology chosen?

-Type and amount of waste treated?

-How and by whom is the waste collected? Where does it originate? Is it source separated?

-Alternative solution and costs if the waste was not composted? (landfill, not collected, burned or given to animals?)

-Have you encountered any technical problems this far and how have you solved them?

-Quality of the treated waste? Contaminations?

-Measured operational parameters? (e.g. temperature, C:N quota, moisture content, organic content, pH)

-Are the measurements done in-house or outsourced?

-What additives are used? (That is material mixed with feedstock or active compost in order to adjust the moisture level, carbon to nitrogen ratio, or porosity to create a favourable condition. Examples of additives are fertilizers, bulking material, inoculating with microbes and urea).

-What amendments do you use? (The materials added to stabilised or cured compost to provide attributes for certain compost products, such as product bulk, product nutrient value, product pH, and soils blend)

-Process control? (Aeration and watering and what operational parameters that are affecting the frequency of these activities)

-Efficiency of the process (Waste treated per time unit)?

-Would it be possible to scale up/scale down the process?

-Quality of end product? (In terms of maturity, organic matter content, the presence of physical contaminants (such as glass, metal or plastic), pH, particle size, nutrient content, moisture content and trace element content such as heavy metals)

-How is the product used?

Environmental Sustainability

-Environmental goals in the project?

-Has an EIA been done? Are the emissions to air water and soil measured? Is the process water treated?

-Does the product have any environmental certifications?

-Is the run off water collected?

-Is any additives (chemical or others) used in the process?

-The construction of the site?

-Location of site?

-Are there or have there been odour problems?

Economic Sustainability

-Incomes from the project?

-Costs of the project?

-Initial costs to set up the facility?

-Alternative treatment costs?

-What are the economical objectives? Is the project profit driven or not?

-Is the end product sold? Does the price correspond to the cost of production?

-Is the project profitable?

-Subsidies or funding?

-Machinery costs?

-Unexpected costs?

-Investment and the running costs?

Social Policies

-Impacts from social policies of job creation, poverty alleviation and BEE?

-Number of persons employed?

-Social background, gender, level of education and skin colour of the employees working with the composting project and the managers and owners?

-Investment in education or skill enhancing among the workers? How is it done?

-Social investment initiatives in health, education, poverty alleviation and community development?

-BEE level?

-Working environment and conditions?

Appendix 2: Contact Information to Visited Projects

Cape Town Municipality

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Johannesburg Municipality

Pickitup

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Breede River Winelands Municipality

Robertson Compost

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Makana Municipality

Mzam' Omhle Project

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Sol Plaatje Municipality

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