Guidelines for the Utilisation and Disposal of Wastewater Sludge, Volume 1-5:

IMPACT ASSESSMENT

Cornelis van der Waal

TT 367/08

Water Research Commission

Guidelines for the Utilisation and Disposal of Wastewater Sludge, Volume 1 – 5: *Impact Assessment*

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Report to the
Water Research Commission

by

Frost & Sullivan

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The release of the 2006 Sludge Guideline series aims to rectify previous sludge guideline shortcomings and provide an easy-to-use management tool for the handling of wastewater sludge. The aim of this project was to quantify the potential impact of the 2006 Sludge Guidelines on South African society by analysing current examples of wastewater sludge best practice that are aligned with the 2006 Sludge Guidelines.

Numerous examples of wastewater sludge handling best practise were reviewed. A variety of organisations benefit economically from the re-use of wastewater sludge and distinct social impacts that stem from these economic benefits were also identified. Environmental impacts have resulted largely from unsustainable sludge handling and mismanagement practices.

The examples identified during the completion of this project clearly reflect that wastewater sludge management practices that are aligned with the 2006 Sludge Guidelines have a significant impact across economic, social and environmental areas of South African society.

1. Introduction

Wastewater sludge management in South Africa today is underpinned by rigorous research and stakeholder participation, which has culminated in the release of a five volume series of wastewater sludge management guidelines, **Guidelines for the Utilisation and Disposal of Wastewater Sludge, Volume 1 - 5**. The Water Research Commission (WRC) has worked closely with a diversity of stakeholders to ensure these guidelines are both suited to local conditions and focused on benefiting the economic, social, environmental and health aspects of South African society.

Various editions of wastewater sludge management guidelines have been produced in the last 25 years. The relatively straightforward wastewater sludge guidelines of 1989 have evolved with time and improved management practices into more complicated guideline documents, such as those released in 1997 and their addendum in 2002. Each guideline released has reflected a change in how wastewater sludge is perceived in terms of its usefulness within society.

Before the release of this latest five volume wastewater sludge guideline series, there was common agreement amongst wastewater sludge management stakeholders in South Africa that the existing guidelines (1997 guidelines) were in need of a revamp. International best practise for wastewater sludge management was evolving and it was decided that South Africa's wastewater sludge management guidelines could be improved. The wastewater sludge management guidelines were republished for the following reasons:

- **Principle of sustainability**

  The 2006 guidelines support the principle of appropriate / sustainable use of resources.
- **Choice of different options**

  The previous 1997 guidelines focused on the use of wastewater sludge as a soil conditioner and were not particularly clear on other options such as disposal to landfill sites.
- **Aligning South African guidelines with international trends**

  The latest 2006 Sludge Guidelines introduce a new sludge classification system that is more in line with international wastewater sludge management trends.

- **Local research knowledge**

  All previous sludge guidelines were based on international research whereas the latest 2006 Sludge Guidelines encompass South African wastewater sludge research.

- **Focused on user-friendliness**

  The previous 1997 sludge guidelines were technical in nature and required some prior knowledge about wastewater sludge management in order to interpret them. The 2006 WRC Sludge Guidelines were written for all readers.

It is important that research and activities conducted by the WRC add value to South African society, which highlights the purpose of this report. The primary thrust of this document is to determine the impact that WRC research and these newly released wastewater sludge management guidelines are having on South African society.

1.1 Aims and Objectives

The aim of this project is to provide a concise assessment of the potential impact of the **2006 Guidelines for the Utilisation and Disposal of Wastewater Sludge, Volume 1 – 5** on socio-cultural, economic, health and environmental aspects of South African society.

In the context of the above aim, the project objectives are:

- To map the full extent of all wastewater sludge-related research and products that have culiminated in the **Guidelines for the Utilisation and Disposal of Wastewater Sludge, Volume 1 – 5** (hereafter 2006 Sludge Guidelines)
- To determine the impact of the 2006 Sludge Guidelines
- To relate the impact of the 2006 Sludge Guidelines to a common measure such as a Rand value
- To determine the potential, broader impact of the 2006 Sludge Guidelines on South African society

1.2 Scope and Aim of Document

1.2.1 Scope

In an effort to retain and strengthen its position as a “value for money” institution delivering research and innovations that contribute to socio-cultural, economic, health and environmental aspects of well-being in South Africa, the WRC has embarked upon a number of studies to assess and portray the impact of it’s research programmes and resulting products and their respective benefits to the country. The results of these studies are shared with industry

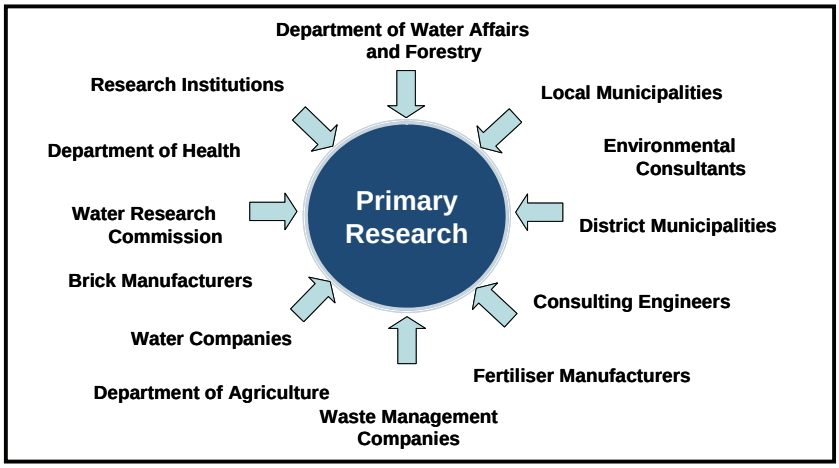
stakeholders such as government organisations, consulting engineers, local government bodies and other users of research.

To ensure objectivity these studies are carried out by independent bodies and for this reason the WRC approached Frost & Sullivan to conduct this research on the impact that the 2006 Sludge Guidelines will have on South African society.

1.3 Project Methodology

A primary research (telephone or face-to-face interviews) approach was used as the principle method of data gathering and populated questionnaires gathered by the WRC during the 2006 Sludge Guideline training sessions and workshops were also analysed.

A total of 45 interviews were conducted during the research process with a broad range of stakeholders. All interview participants and stakeholders consulted during the project have been outlined in the diagram below:



1.4 Background to Wastewater Sludge Management Research

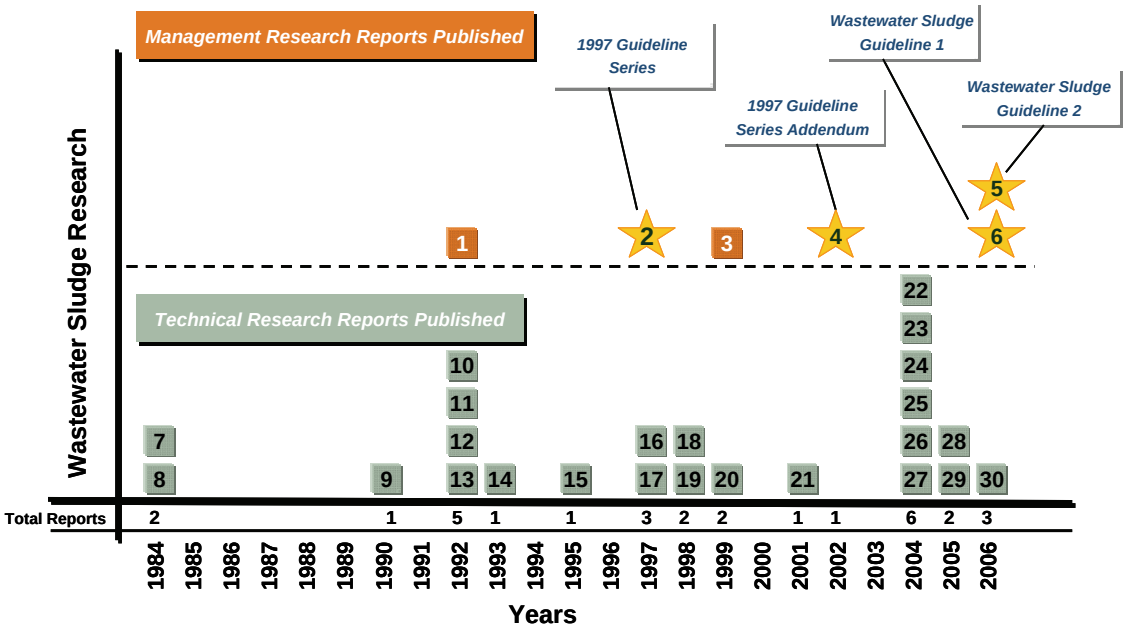
The WRC's research in the area of wastewater sludge management is aimed at developing technologies and systems that optimise the wastewater and waste management chain. The WRC has taken the view that wastewater and wastewater sludge in particular has a definite value that can be utilised for economic benefit.

The core objectives of WRC wastewater sludge management research are:

- To provide knowledge that ensures reliable, affordable and efficient water use and waste management services to enhance the quality of life, and contribute to economic growth and improved public health.
- Develop new approaches to manage and enhance hygiene and sanitation practices
- Develop applications for improved treatment of wastewater and effluent and improve processes for enabling increased reuse thereof.

2. A History of Wastewater Sludge Management Research in South Africa

Since 1984 the WRC has produced a broad range of wastewater sludge management research that has focused primarily on issues of a technical nature. Wastewater sludge management in South Africa has evolved considerably as research conducted by the WRC has developed and improved upon sludge handling techniques. This research has directly influenced each wastewater sludge guideline that have been produced. The figure below, read in conjunction with appendix 1, provides an overview of all the wastewater sludge related research that has been conducted by the WRC.



Please refer to appendix 1 for the list of research reports published

Wastewater sludge management is the responsibility of local authorities; however the 1970's saw the Department of Health take a leading role in the management and disposal of sludge. Section 20 of the National Health Act (Act 63 of 1977) provided general provisions that in principle encapsulated the management of sludge, but included no specific sludge handling provisions.
In 1989, the Department of Health released some guidelines for the use of sewage sludge, which had the following benefits:

- All types of sewage sludge may be utilised;
- A limited number and only essential requirements and conditions are imposed;
- A limited number of quality control determinations are required;
- Some flexibility in application will be allowed; and
- The unsatisfactory impact on human health and the environment should be minimized to acceptable levels

It was only in 1989 that, with the formation of Sludge Management Working Group and later the Sludge Management Division of the Water Institute of Southern Africa that the sludge information document, "Sewage sludge utilisation and disposal information document" was compiled.

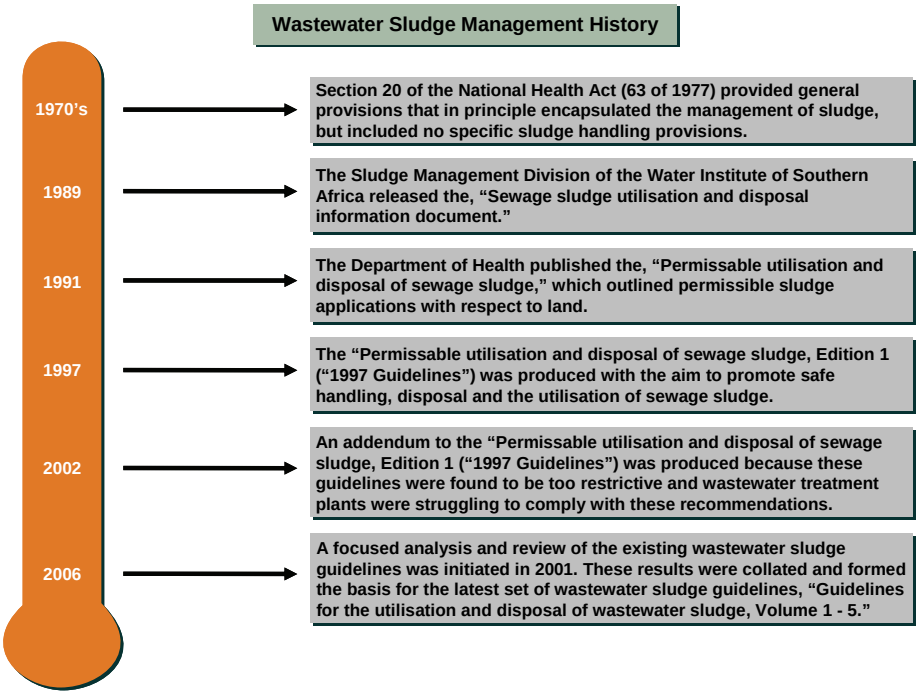
Further the Department of Health published the, "Permissible utilisation and disposal of sewage sludge," in 1991, which outlined permissible sludge applications with respect to land.

An interesting difference between the 1989 and 1991 sludge publications was the permissible metal concentrations within sludge. This resulted in an extended debate between all industry stakeholders, which included the Department of Health, Department of Water Affairs and Forestry, Department of Agriculture and the Department of Environment Affairs and Tourism.

Finally, in 1997 the "Permissable utilisation and disposal of sewage sludge, Edition 1" (1997 Guidelines) was produced with the aim to promote safe handling, disposal and the utilisation of sewage sludge.

However, the 1997 Guidelines were found to be overly restrictive, particularly with regard to the metal concentrations within sludge, which impacted negatively on sludge management practices and wastewater treatment plants struggled to comply with these recommendations. Hence, in 2002 an addendum document to the 1997 Guidelines to assist with their interpretation was published.

Figure 1: An Overview of Wastewater Sludge History in South Africa



Wastewater Sludge Management Guidelines

The debate around acceptable wastewater sludge management practices and metal concentration levels, in particular, has been lengthy. To address these issues, the WRC in 2001 embarked on a program to critically review and assess the existing South African sludge management guidelines and legislation with the aim to adding to the South African wastewater sludge management knowledge base.

Research projects that were commissioned particularly for this purpose included:

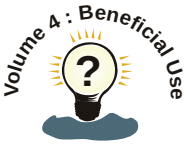
WRC: 2001 Critical Review of Sludge Legislation Research	
1283	A metal content survey of South African sewage sludge and an evaluation of analytical methods for their determination in sludge
1240	A technical and financial review of sludge treatment technologies
1209	An evaluation of dedicated land disposal practices for sewage sludge.
1339	Survey and methodology for analysing organic pollutants in South African sewage sludge
1210	Laboratory and field scale evaluation of agricultural use of sewage sludge

The results from these research projects were collated and combined with previous research and stakeholders input and used for the compilation of the latest 2006 Sludge Guidelines. Five volumes of these guidelines are to be published as detailed below:

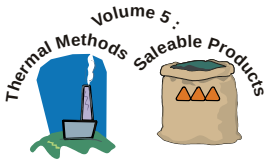
Volume 1: Selection of Management options: volume 1 describes the initial comprehensive characterization of sludge. Based on the results of characterization, appropriate management options can be selected for a particular case. The document directs the reader to the appropriate guideline volume to use.

Volume 2: Requirements for the agricultural use of sludge: volume 2 describes the requirements and restrictions related to the safe use of sludge for the production of crops.

Volume 3: Requirements for the on-site and off-site disposal of sludge: volume 3 describes the requirements and restrictions related to the on-site and off-site disposal of



Volume 4: Requirements for the beneficial use of sludge: volume 4 describes the requirements and restrictions pertaining to the beneficial use of sludge.



Volume 5: Requirements for thermal sludge management practices and for commercial products containing sludge: volume 5 is divided into two parts: part 1 addresses the use of thermal methods to manage sludge and part 2 addresses the use of sludge to manufacture saleable products.

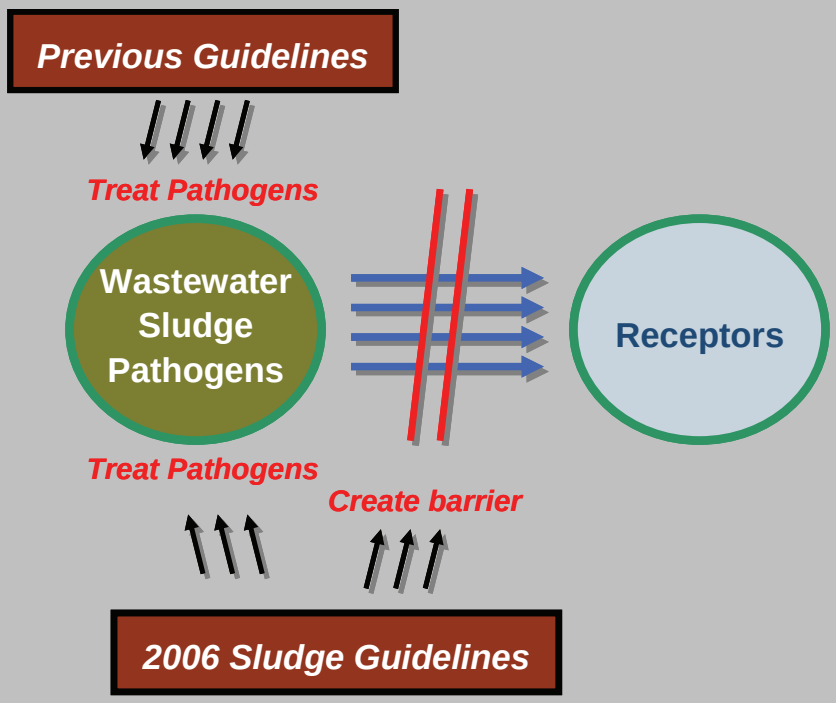
Pathogens in Sludge

Untreated wastewater sludge is rich in pathogens so management and handling practices need to ensure that there are no adverse environmental or health impacts for end users. Brick and fertiliser manufacture includes a heating phase, which ensures that all pathogens are destroyed and metals are converted to an insoluble fraction, while farming land application requires specific management protocols. Classification of sludge and strict management practices relating to the management of sludge and its pathogens are outlined in Volume 5 of the 2006 Sludge Guidelines.

Risk Management

An important difference between previous sludge guidelines and the 2006 Sludge Guideline series is the principle of risk management. High pathogen levels within wastewater sludge present definite risks for wastewater sludge managers and end users. Previous guidelines managed this risk by ensuring that wastewater sludge was treated to a particular specification by wastewater sludge managers. This treated wastewater sludge was then released for re-use by end-users. The challenge with this approach was that if re-used sludge was not treated to

adequate levels there was no control over the management of this sludge and the potential exposure to its high pathogen levels once re-used.



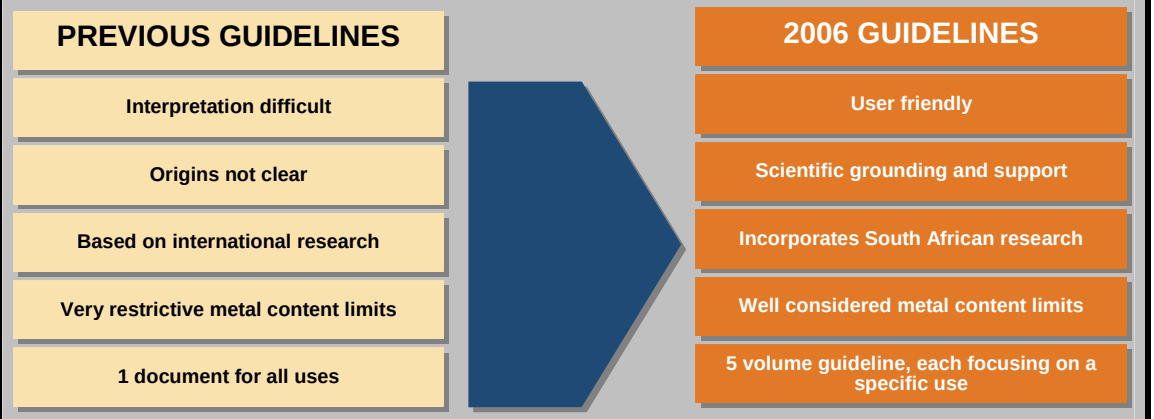
The 2006 Sludge Guidelines have adopted an additional line of defense when managing these risks. Not only does wastewater sludge need to be treated to adequate specifications, but the 2006 Sludge Guidelines also include specific sludge handling and management practices for when wastewater sludge is being re-used, which ensures that a barrier is created between the pathogen-containing sludge and potential receptors. This provides a second line of defense against the pathogens found in the wastewater sludge. For example, when sludge is used for land application the 2006 Sludge Guidelines insist that the sludge is ploughed into and covered with soil immediately to reduce the risk of contact.

A COMPARISON BETWEEN PREVIOUS WASTEWATER SLUDGE GUIDELINES AND THE 2006 WASTEWATER SLUDGE GUIDELINES

The 2006 Sludge Guidelines are significantly different from previous guidelines and provide industry stakeholders with numerous benefits over previous versions. The 2006 Sludge Guidelines are a user-friendly 5 volume series that are grouped according to a particular management option.

- Previous guidelines were typically one document that attempted to address all the different wastewater sludge management approaches.
- Previous guidelines were typically technical in nature, which did not make them particularly user-friendly.

The 2006 version has opted to handle each management option in a separate volume, which simplifies the documents for readers. In addition, each version is all encompassing and focuses on the characterization of a particular sludge as well as the management, technical and legislative aspects of wastewater sludge handling.



3. Impact of Wastewater Sludge Management Research and Sludge Management Guidelines in South Africa

3.1 Impacts

The 2006 Sludge Guidelines will have both a quantitative and qualitative impact on economic, environment, social and health realms of South African society. Each of these areas plays an important, but different role within South African society and it is important that the potential impact of the 2006 Sludge Guidelines is assessed.

Little time has passed since the release of the 2006 Sludge Guidelines, hence there has been limited application of these new sludge management principles by local authorities across South Africa. It has therefore been difficult to identify impacts that have arisen as a direct result of applying these latest guidelines. However, numerous examples have been identified where local authorities and wastewater sludge end-users have, through experience and best practise, adopted wastewater sludge management procedures that are aligned with the latest 2006 Sludge Guidelines.

As a result, direct 2006 Sludge Guideline impacts have not been identified, but it is possible, from these examples of best practise, to quantify the future potential impact of implementing the 2006 Sludge Guidelines across South Africa.

Health Impacts

Historically the original wastewater sludge guidelines were created through close collaboration with the Department of Health which ensured that a high health standard was implemented and this has remained an important focus in all versions of wastewater sludge guidelines produced. As a result wastewater sludge management guidelines in South Africa have resulted in adequate health standards being maintained at all times and during this project process no recorded health incident as a direct result of poor sludge management could be found in South Africa. For this reason the impact of the latest 2006 Sludge Guidelines on health in South Africa was not considered a core focus area.

3.2 Assumptions

Impact assessment, particularly related to research and specific activities, can be a challenging and sometimes subjective process. In light of this, this project has aimed to utilise a common

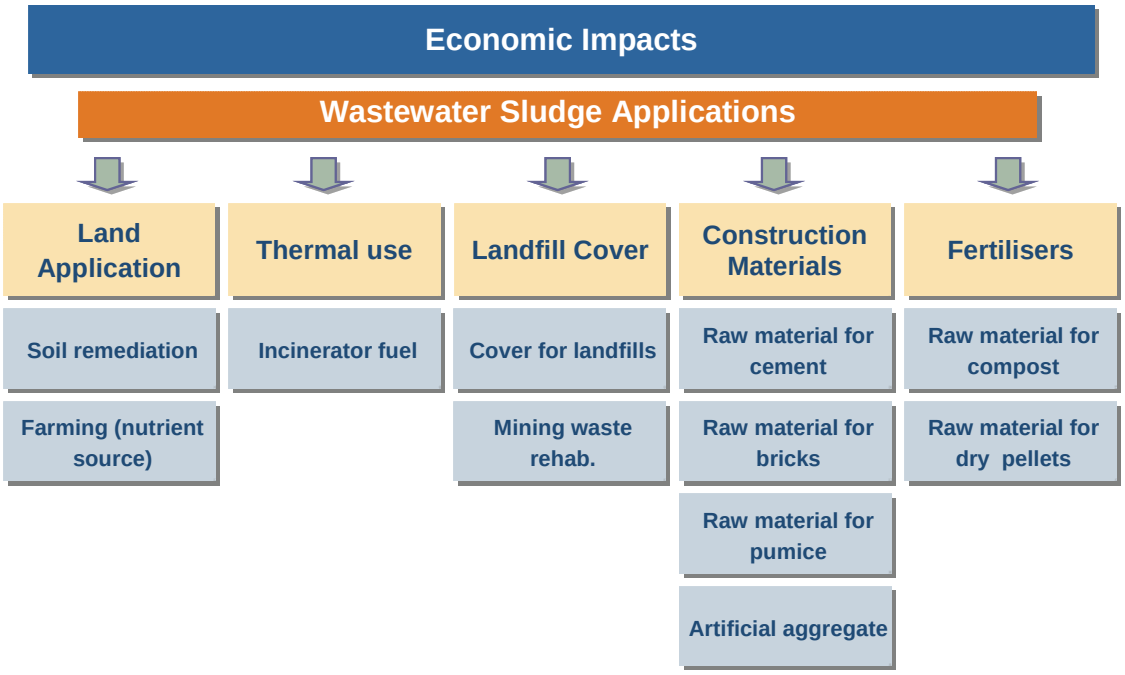
quantifiable measure that is both relevant and measurable across the three impacts areas, namely economy, environment and society.

For this reason, a focus of this project was to try and quantify each impact identified across the impact areas. This was not always possible, owing to the qualitative nature of some of the research areas, however where possible this was conducted.

3.3 Economic Impacts

3.3.1 Introduction

The 2006 Sludge Guidelines recognise the value of wastewater sludge and encourage its reuse for economic benefit. The 2006 Sludge Guidelines have identified several beneficial uses for wastewater sludge and they actively encourage use within these applications. Previous guidelines focused only on land use, but the 2006 Sludge Guidelines expand these to include other broader applications.



A core focus of this project was to assess the potential economic impact of the 2006 Sludge Guidelines in South Africa; a market and company-specific analysis was conducted on aspects of wastewater sludge utilisation within the South African economy to determine this impact.

3.3.2 Quantification of Impacts

Numerous examples of wastewater sludge reuse have been identified; the following areas were focused on:

Brick manufacture

The 2006 Sludge Guidelines encourage the utilisation of wastewater sludge as a raw material for brick manufacture. Volume 5 of the new guidelines addresses the use of wastewater sludge for commercial purposes. A core aim of these guidelines includes:

- To present restrictions and requirements applicable to the use of sludge for commercial purposes applied in construction (brick, cement, etc.).

Fertiliser manufacture

The 2006 Sludge Guidelines encourage the utilisation of wastewater sludge as a raw material for fertiliser manufacture. Volume 5 of the guidelines addresses the use of wastewater sludge for commercial purposes. A core aim of these guidelines includes:

- To present operational guidelines for composting of sludge and restrictions and requirements for other commercial products to be used as fertiliser.

Agricultural Use

Wastewater sludge has many beneficial soil conditioning and fertilising characteristics because of its organic properties that are essential for plant growth. An important focus of the 2006 Sludge Guidelines is that wastewater sludge can be recycled for use on agricultural land, however the processing and application of sludge to land requires careful management.

Volume 2 of the 2006 Sludge Guidelines is dedicated to the agricultural use of sludge; it views sludge not just as a waste product but as a valuable resource that can add value. An important focus of volume 2 of the 2006 Sludge Guidelines is:

- Encourage the appropriate use of sludge in agricultural practices
- Provide guidance on how to maximize the beneficial properties of sludge when applying sludge at agronomic rates

The 2006 Sludge Guidelines view wastewater sludge as a valuable resource when used as a fertiliser and soil conditioner. Important benefits of wastewater sludge include:

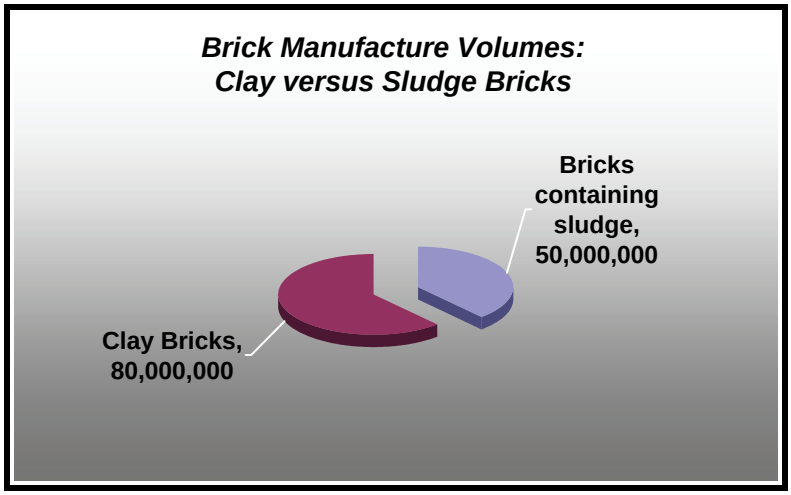
- Supply of major plant nutrients (calcium, magnesium, potassium, phosphorus, nitrogen);
- Supply of some essential micronutrients (zinc, copper, molybdenum and manganese),

- Improvement in soil physical properties, i.e. better soil structure, increased water retention capacity and improved soil water transmission

Brick Manufacture

The utilisation of wastewater sludge in the brick manufacturing process has resulted in significant cost savings for brick manufacturers.

Bricks are manufactured from incinerator ash as well as dewatered wastewater sludge. The brick manufacturer researched during this project manufactures 130 million bricks per annum, of which 50 million are manufactured with wastewater sludge as a component of the raw material. Wastewater sludge has good combustion properties and when used as a raw material brick companies are able to make significant cost savings.



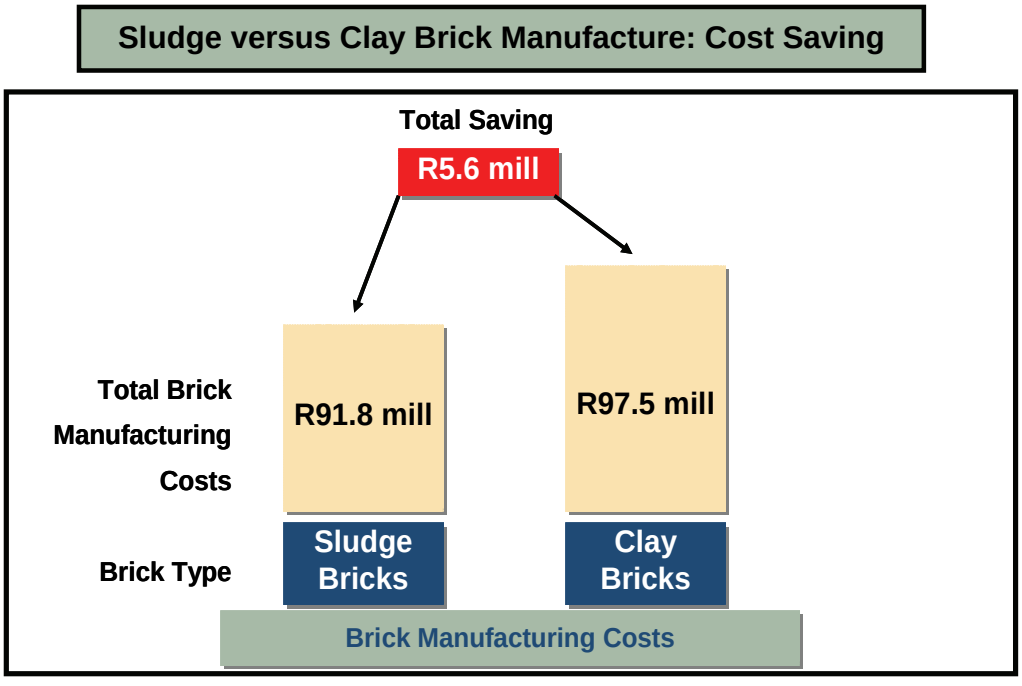
Depending on the quality of the bricks, the wastewater sludge content may range from 10% in high quality bricks up to 30% in poorer quality bricks. When clay bricks are manufactured furnace oil is added as a raw material to ensure that the bricks burn internally, which ensures that they harden throughout and maintain their structural integrity. With the inclusion of wastewater sludge as a raw material, brick manufacturers now do not have to add furnace oil as a raw material to the bricks because the solids within the wastewater sludge are combustible, which ensures that the brick is heated throughout and hardened effectively. This results in a significant cost saving for the manufacturer because less furnace oil is required, which lowers the total energy costs. An analysis of brick manufacturing companies that utilise wastewater sludge as a raw material revealed that cost savings of as much as 30% have been recorded. An additional advantage is

that the wastewater sludge that is utilised is delivered as wet sludge (not dewatered) so less water is required when manufacturing the bricks.

Cost Savings

The brick company analysed during this assessment manufactures 1000 clay bricks for approximately R750, but when wastewater sludge is included as a raw material the cost per 1000 bricks is reduced to R637,50. Based on the total number of bricks produced by this company on an annual basis, the utilisation of wastewater sludge as raw material results in a cost saving of approximately R5.6 million per annum.

Brick Manufacturing Costs	
Brick Type	**Cost per 1000 bricks**
Clay bricks	R750
Sludge bricks	R637,50
Volume of sludge utilised / annum	40 000 tons



Implications for South Africa

Based on the above example it is evident that if implemented effectively the 2006 Sludge Guidelines could have a significant impact on the brick manufacturing industry in South Africa. The provisions included in the guidelines enable brick manufacturers to potentially make significant cost savings and if rolled out on a larger scale the impact could be extraordinary. Further, there is also high potential for wastewater sludge utilisation within related industries such as cement and pumice manufacture.

Fertiliser Manufacture

Wastewater sludge fertiliser products are classified as, but not limited to, either compost or pellets. Composting is the process whereby sludge is decomposed and stabilized under aerobic conditions that promote the development of thermophilic temperatures as a result of biological action. If the compost manufacturer follows the recommended procedures the final product is humus-like, stable and free of pathogens and plant seeds and can be successfully added to land.

Pelletisation is the process whereby sludge is converted into dry, pathogen-free granules that can either be used as a fertiliser or a fuel.

Industry Challenges

There are some challenges associated with the perception of wastewater sludge for fertiliser, but these are because of the early development stage of the market. Some users of compost and fertiliser are not comfortable with the idea of using wastewater sludge as a raw material and certain international trade organisations will not accept fresh produce that has been grown utilising wastewater sludge-based fertiliser products. However, despite these challenges, compost manufacturers are able to produce a high quality soil amendment product that is gaining popularity in the market because of its soil conditioning abilities.

Wastewater sludge has been identified as an effective raw material for fertiliser manufacture. The City of Cape Town utilised approximately 20 000 m^3 of wastewater sludge for the manufacture of fertiliser during the period June 2003 until July 2004.

Wastewater sludge fertiliser products can be registered as quality grade agricultural fertiliser in South Africa. The pelletisation of wastewater sludge produces a dry and highly effective fertiliser product.

Successful fertiliser businesses have been created as a result of good sludge management practices. Two wastewater sludge fertiliser businesses were reviewed during this study and both organisations were started as a result of the opportunity created by the provision to use wastewater sludge for fertiliser production.

Fertiliser Company Revenues		
Product	**Volumes**	**Revenue / annum**
Business 1		
Dry compost product	24 tons/day	R2.2 million
Compost land application	48 tons/day	R4.3 million
Business 2		
Dry fertiliser product	10 tons/day	R600 000
Total Revenue Generated		**R7.1 million**

As detailed in the table above, significant revenues are created by companies through the utilisation of wastewater sludge. Business 1 generates approximately R6.5 million in revenue per annum and a smaller business generates approximately R600 000 in revenue per annum.

Implications for South Africa

The examples provided above are only a snapshot of the current as well as the potential impacts that wastewater sludge is having / can have within the fertiliser sector. Just on this local scale the utilisation of sludge through sludge management best practices that are aligned with the 2006 Sludge Guidelines is having a significant impact in the generation of revenue. If the 2006 Sludge Guideline management principles with regard to fertiliser were expanded across South Africa the impact could be significant.

How have the 2006 Sludge Guidelines impacted your fertiliser business?

"The wastewater sludge guidelines have impacted our business very positively. It is a clear, readable and practical document to guide both local authorities and entrepreneurs in the disposal of wastewater sludge. " **Agriman Fertiliser Company**

Cost Savings for Municipalities

The City of Cape Town (COCT) has adopted wastewater sludge management best practices that are aligned with the 2006 Sludge Guidelines. The unsustainable method of wastewater sludge landfill disposal coupled with the limited availability of landfill space in Cape Town has encouraged the COCT to actively pursue alternative applications for their wastewater sludge. Currently the COCT utilises their sludge for the following applications:

- **Composting**
- **Land application – farming**
- **Land application – roll-on lawn**
- **Pelletisation**

The COCT disposes the following volumes of wastewater sludge for these applications:

Application	Dry tons per annum
Composting	**9120**
Land application – farming	**13 440**
Land application – roll-on lawn	**192**
Pelletisation	**3420**
Total	**26 172**

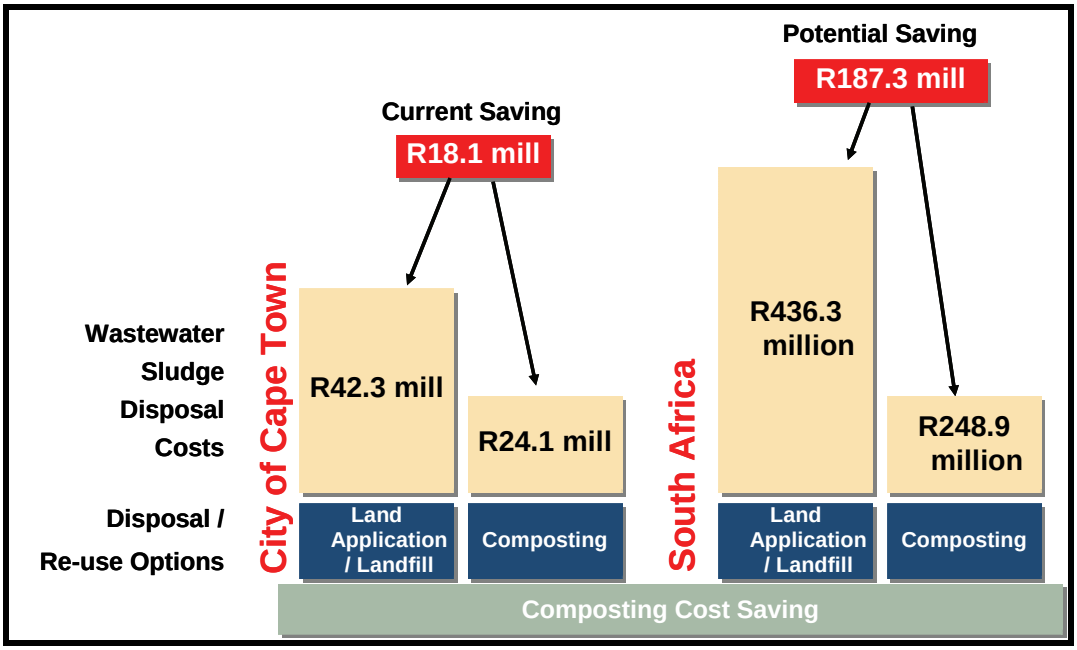
A total of 26 172 dry tons of wastewater sludge is utilised for useful application by the COCT on an annual basis, which constitutes approximately 42% of all sludge produced by the city. Wastewater managers believe this figure would be over 70% if all wastewater sludge dewatering equipment was fully operational.

Wastewater Sludge Disposal Facts	
200 000 ML	Approximate volume of wastewater treated by the City of Cape Town per annum
62 233 dry tons	Amount of dewatered wastewater sludge processed by the City of Cape Town per annum

20 000 m^3	Volume of sludge composted in the City of Cape between June 2003 and July 2004
6 years	The number of years which a City of Cape Town landfill site's lifespan was extended by supplying wastewater sludge to one fertiliser manufacturer.
R680,08/dry ton	The cost for a wastewater treatment facility to dispose of 1 dry ton of wastewater sludge at a landfill site or land application.
R388,04/dry ton	The cost for a wastewater treatment facility to dispose of 1 dry ton of wastewater sludge via a fertiliser company.

The stringent metal limits in the 1997 wastewater sludge guidelines meant that municipal wastewater treatment works had to dispose of their wastewater sludge at landfill sites, which was expensive (R680,08/dry ton) and it wasted space in the landfills that could have been used for more important hazardous waste. It also shortened the total lifespan of the landfill site. Through wastewater sludge management best practise, the COCT has been able to have an important impact on the lifespan of hazardous landfill sites.

The method of wastewater sludge disposal adopted by wastewater sludge managers can have important cost saving implications. In the COCT it costs R680,08 per dry ton to dispose wastewater sludge to landfill sites or through land application, but it costs R388,04 per dry ton to dispose of wastewater sludge through composting. Based on the volumes produced by the COCT on an annual basis, if all of their sludge was used for composting purposes this would result in a saving of approximately R18.1 million per annum, as outlined in the diagram below.



Further, based on the average wastewater sludge production rate per person in Cape Town, if all wastewater sludge in South Africa was utilised for composting this would result in a saving of approximately R187,30 per annum for wastewater sludge managers across South Africa. Of course, this is an unlikely scenario, but it does highlight the cost saving impact that best practise wastewater sludge management, as outlined in the 2006 Sludge Guidelines, can have across South Africa.

Agricultural Use

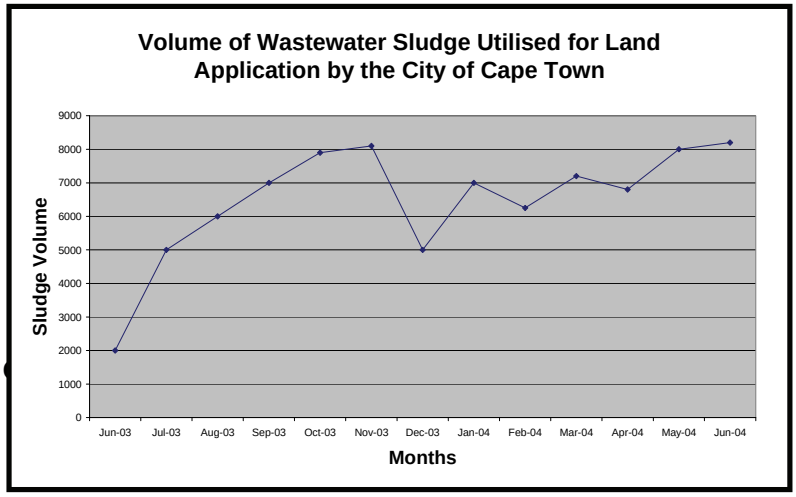
The application of wastewater sludge to arable land is an effective method for municipal wastewater treatment works to dispose of their wastewater sludge. The disposal of sludge to landfill sites is both expensive and it is a waste of valuable landfill space.

When applied correctly, farmers welcome the application of wastewater sludge to areas with poor soils. The high organic content of wastewater sludge improves the nutrient levels within poor soils and sludge-treated sandy soils are able to trap and retain more water.

Farmers in the Swartland region of the Western Cape have struggled to produce profitable yields because of the soils low nutrient levels. The land application of wastewater sludge has significantly improved the nutrient and moisture content of these soils and farmers have been able to realise profitable yields from previously unprofitable areas. Land application requires careful management, but when applied correctly, as displayed in the photo alongside, the results are positive.

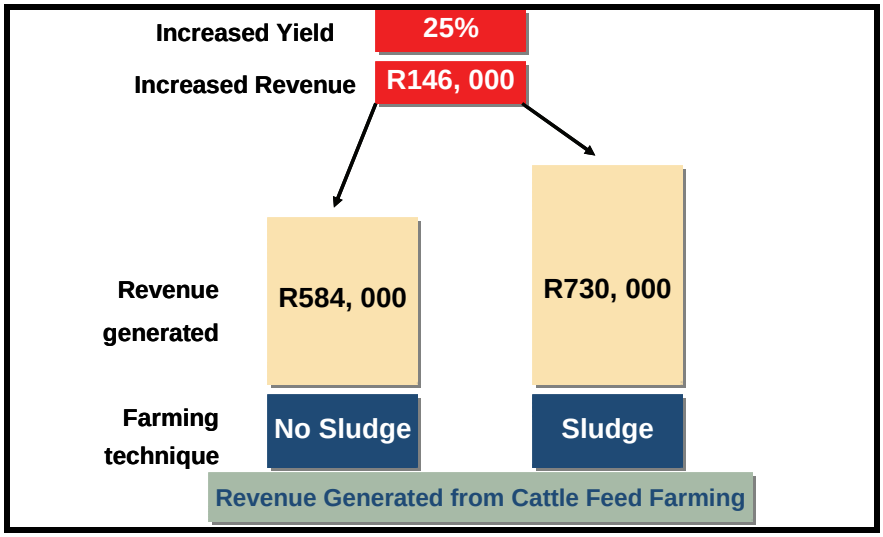
This field was not utilised for 12 years because of poor sandy soils and low crop yields. One application of wastewater sludge was successful and produced a good yield, as is evident in the photo. The land application of wastewater sludge not only improves the nutrient content of the soils, but the moisture content levels improve as well.

This photo clearly depicts the superior plant and root stocks that can be achieved by utilising wastewater sludge for land application. The plant on the right hand side was grown in a field that was treated with wastewater sludge while the left hand plant was grown in an untreated field.



For the period June 2003 until July 2004 approximately 80 000 m^3 of wastewater sludge was used successfully for agricultural land application practices in the Swartland. When wastewater sludge is applied to arable land the characterization of the sludge, in terms of its microbiological, stability and pollutant classes, dictates the type of crop that can be grown.

A dairy farm in the West Coast region of the Western Cape is characterised by sandy soils that are nutrient poor and which struggle to retain water. The farm grows animal feed for their dairy cows, but the local soil characteristics make feed production a challenge. The application of wastewater sludge to this farm's fields has made a significant difference to yields.



As depicted in the diagram above, total annual yields have improved by 25% as a result of wastewater sludge land application, and increased total revenues from approximately R584 000 up to R730 000. The farmer also believes that the cattle prefer feed that has been grown in wastewater sludge-treated soil and the water retention abilities of these soils is also said to be superior to untreated sandy soils in the area.

Implications across South Africa

The example highlighted above is only a small insight into the impact that good wastewater sludge management and disposal practices, as outlined in the 2006 Sludge Guidelines, can have through land application. If the 2006 Sludge Guidelines were implemented across South Africa and land application was carried out the impact on farming yields and costs would be significant.

3.3.3 Case Studies

Case Study 1: *COEGA BRICKS*

Coega Bricks were the pioneers for utilising wastewater sludge for the manufacture of bricks in South Africa. Historically, Coega Bricks only utilised clay as a raw material for brick manufacture, but when it was evident that wastewater sludge could be a potential source of raw material, Coega Bricks decided to explore the opportunity of supplementing their clay with dewatered wastewater sludge. Experiments were conducted to assess the combustion properties of wastewater sludge as it was suspected that it may be a good material to mix in with the standard clay raw material. The experiments were a success and Coega Bricks started sourcing wastewater sludge from the local wastewater treatment works.

Case Study 2: *AGRIMAN FERTILISER MANUFACTURER*

Agriman (Pty) Ltd (Agriman) utilises wastewater sludge as a raw material for their fertiliser products. The wastewater sludge fertiliser market is relatively small in comparison to the chemical fertiliser market, but it possesses much potential. Agriman are of the opinion that the chemical fertiliser industry producers approximately 2.1 million tons of product per annum, but Agriman, as one of the only wastewater sludge fertiliser manufacturers in South Africa produces only about 3000 tons of product. Interestingly, Agriman are of the opinion that farmers are moving away from chemical fertilisers because of the global move towards organic and biological fertilising processes, with which the wastewater sludge fertilisers are aligned, which bodes well for this industry. Discussions with Agriman have revealed that the utilisation of wastewater sludge as a raw material has had a significant impact on their business.

Case Study 3: *CITY OF CAPE TOWN LAND APPLICATION*

The City of Cape Town wastewater treatment works processes approximately 200 000 megalitres of wastewater on an annual basis, which equates to approximately 5 million m^3 of wastewater sludge per annum. Through dewatering processes this volume of sludge is further reduced to approximately 333 000 m^3, which is enough sludge to fill a soccer field to a depth of 66 meters!

Historically, with the stringent metal content standards for sludge, the majority of this sludge was disposed of at hazardous landfill sites, which was expensive and it took up valuable landfill space that should have been utilised for hazardous materials. With the allowances included in the 2006 Sludge Guidelines the City of Cape Town was able to consider alternative disposal methods other than landfill disposal. As per the guidelines, the sludge was deemed suitable for the following applications:

- **Land application for cereal culture**
- **Grazing for animals**

There were however some restrictions:

- **Sludge has to be applied prior to planting**
- **The sludge has to be covered with soil**

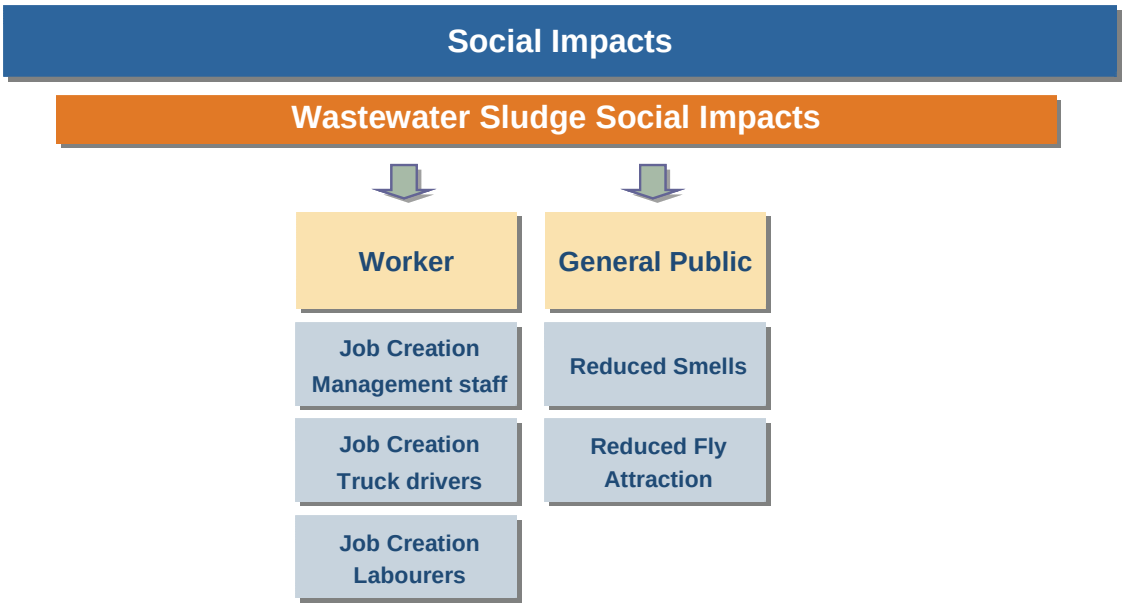
The agricultural region of the Swartland was deemed the best area for land application owing to its predominantly sandy soils with low organic and metal content levels.

3.4 Social Impacts

3.4.1 Introduction

The practicalities of wastewater management are an important aspect of society that needs to be managed effectively to ensure that all South African citizens can reap the benefits of adequate wastewater management. All South Africans should have access to adequate sanitation, but also, importantly, where the possibility arises citizens should be allowed to benefit economically from the beneficial use of wastewater sludge.

Practically analysing and quantifying the impact of wastewater sludge management best practise, which is aligned with the 2006 Sludge Guidelines, on social aspects of South African society is not an easily definable task. However, it is apparent that through the promotion of the beneficial utilisation of sludge there have been some social benefits.



Social impacts that have arisen from wastewater sludge best practise are focused on job creation and the improvement of nuisance effects stemming from wastewater sludge disposal.

3.4.2 Quantification of Impacts

Job Creation

Various organisations have been identified that utilise wastewater sludge in a beneficial manner, which either generates income for them or results in significant cost savings. In addition to these direct impacts, there are also additional social knock-on effects that cannot be ignored.

These companies, by applying wastewater sludge management best practise, are utilising sludge for their benefit and in the process creating various job opportunities. Job creation is vital for empowering individuals, while it also has direct social knock-on effects for the impacted communities.

Company	Position	Staff	Monthly salary	Annual Contribution
Agriman Fertiliser Manufacturers	Labourers	5	R4 000	R240 000
	Manager	2	R10 000	R240 000
Brunig Compost Processors	Labourers	9	R2 500	R270 000
	Managers	2	R7 000	R168 000
Coega Bricks	Drivers	2	R8 000	R192 000
Eco Grow	Labourers	4	R3 000	R144 000
	Manager	1	R9 000	R108 000
Swartland Farm 1	Farm workers	3	R7 000	R252 000
	Managers	2	R13 000	R312 000
Swartland Farm 2	Farm workers	4	R5 000	R240 000
	Managers	2	R10 000	R240 000
Total		**36**		**R2 406 000**
Total semi-skilled jobs		**25**		
Total skilled jobs		**11**		

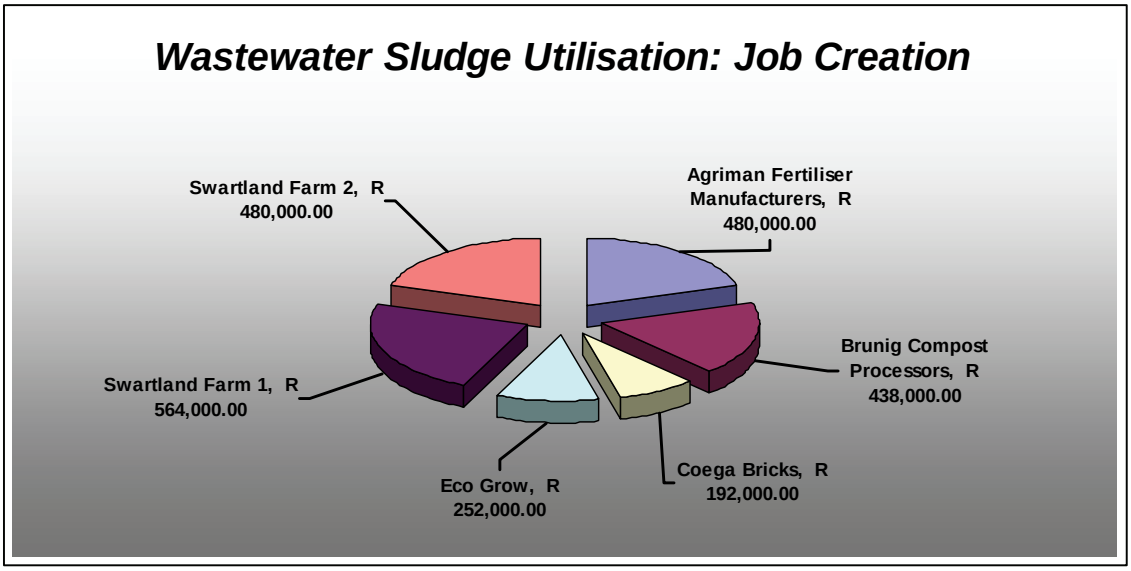
The above companies were analysed in terms of jobs that were created as a direct result of utilising wastewater sludge. From the table above, which summarises the positions, monthly salary and total annual contribution for employees within each company it is evident that the utilisation of wastewater sludge, within this handful of companies, has had a significant impact. A total annual amount of R2 406 000 in paid salaries resulted from the utilisation of wastewater

sludge. The majority of the jobs created involve semi-skilled and skilled people. Of the 36 jobs created a total of 25 are semi-skilled and typically involve tasks related to the handling and application of sludge. Eleven skilled positions were created, which result in higher monthly and total annual contributions, and typically involve the management of other staff.

Implications for South Africa

These jobs highlighted in this example are just the tip of the iceberg; if companies across South Africa were established to take advantage of sludge re-use the social impact would be significantly more than what is outlined. South Africa has a distinct challenge in the form of high unemployment levels amongst semi-skilled people. Sectors or industries that are able to create jobs and employ semi-skilled people are important contributors to the drive to curb unemployment.

The graph below compares the companies analysed in terms of their total annual salary contributions. These companies are making significant total annual contributions to their staff, which also has an important knock-on affect within their local communities. Semi-skilled and skilled workers are often sole, or at least important, breadwinners within their families and communities.



Reduced Smell and Fly Impacts

A social aspect of wastewater sludge management in South Africa is that of olfactory (smell) and fly impacts. These impacts are difficult to quantify, but for the sake of completeness, it was deemed important to include these in this study.

Untreated wastewater sludge can give off strong odours and during onsite or off-site disposal and land application this can have a definite impact on surrounding areas and communities. During this project it was revealed that there have been cases where communities neighbouring areas where wastewater sludge has been applied to farmland have complained about the associated smell. In these cases farmers endeavoured to mitigate the smell, as outlined in the 2006 Sludge Guidelines, by applying alternative application techniques such as ploughing the wastewater sludge into the soil immediately and only applying sludge when the correct wind was blowing.

An additional challenge associated with smell impacts is that of flies. When wastewater sludge is applied to land, unless the sludge is ploughed into the soil immediately, flies are attracted to the site to lay their eggs. This can lead to incidences where high numbers of flies hatch and can therefore be found in surrounding areas. The 2006 Sludge Guidelines suggest practical sludge handling techniques to mitigate this impact.

3.5 Environmental Impacts

3.5.1 Introduction

Wastewater sludge has had a variety of impacts on the environment in South Africa. Limitations with past wastewater sludge guidelines, specifically related to the handling of sludge on and surrounding wastewater treatment works, has created a situation where significant quantities of wastewater sludge have been stockpiled within and surrounding wastewater treatment facilities or in some extreme cases dumped on uninhabited land.

Mismanaged wastewater sludge can have a considerable negative impact on the environment.
An aim of this project was to determine the impact that the 2006 Sludge Guidelines could have on environmental aspects of South African society.

Volume 3 of the WRC's Sludge Guidelines includes several requirements that ensure the correct handling and disposal of wastewater sludge within a wastewater treatment facility. The aim of this volume includes:

- Provide guidance on selection of appropriate disposal options
- Create an understanding of operational and legal requirements for different disposal options
- Provide guidelines for the monitoring of disposal sites

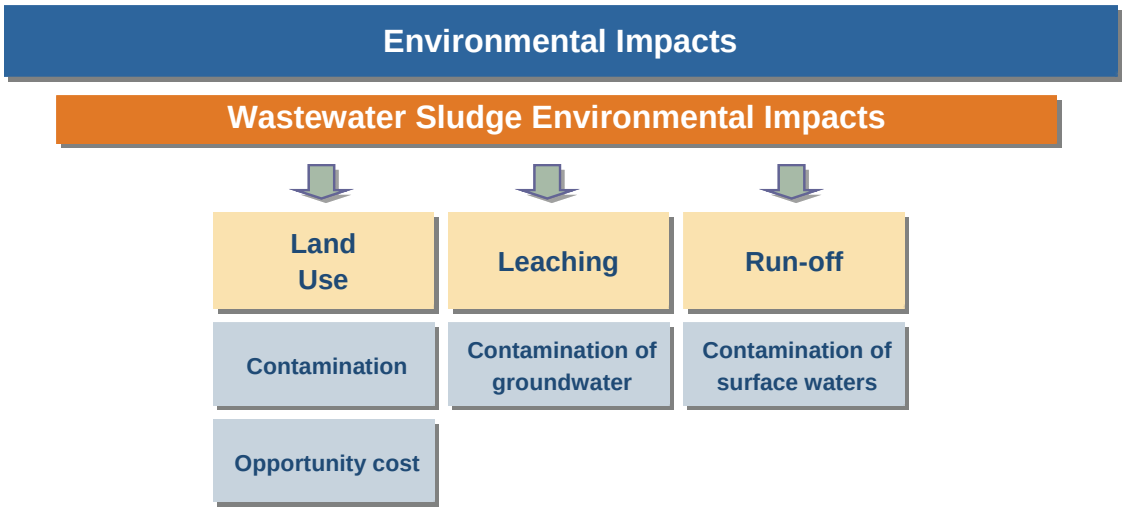
Within volume 3 of the guideline the following principles are encouraged:

- The beneficial use of the sludge is recommended where possible
- Sludge disposal is seen as a last resort
- Producers of sludge must provide proof that they have
  - Considered alternative uses / management
  - Tried to improve the quality of the sludge

In addition, correct site selection, investigation, management requirements, sludge monitoring, groundwater, surface water and soil monitoring are outlined.

Quantifying environmental impacts can be a challenge, but one approach is to assess the damage caused by poor sludge handling and then quantify the cost to rectify or remediate the impacted area. One can then deduce that if the 2006 Sludge Guidelines had been implemented these costs would not have been incurred.

The 2006 Sludge Guidelines identify that stockpiled or dumped wastewater sludge can impact local water courses through run-off. A second impact that is not within the scope of the 2006 Sludge Guidelines is land contamination and the opportunity cost of not being able to utilise that section of real estate. These impacts have been outlined in the diagram below:



3.5.2 Quantification of Impacts

Land Contamination

Pre-2006, the restrictive nature of wastewater sludge guidelines limited the extent to which wastewater managers could dispose of and manage their sludge. For example, overly restrictive sludge metal limits created the situation where certain wastewater sludge was classified as a hazardous material and needed to be disposed of at a hazardous landfill site, which was both expensive and a waste of valuable hazardous landfill space, which was often not available.

A result of this was that wastewater treatment works that could not comply with these overly stringent guidelines either dumped their wastewater sludge within the precinct of their wastewater treatment facility or on land adjacent to the facility. Also, wastewater treatment facilities made extensive use of wastewater sludge drying beds, as depicted in the photo below.

Wastewater treatment facilities were historically located on the outskirts of urban areas, but with increasing population levels and high urbanisation rates cities have slowly expanded and encroached on these wastewater facilities as land, especially for residential housing, has become increasingly scarce. A problem in some areas is that this land has been utilised as a sludge dumping area and, in its current state, is not fit for human habitation. In addition, some tracts of land within larger wastewater treatment facilities that are currently unutilized are also being earmarked for development, but these sites have been used as sludge drying beds or dumping areas and require rehabilitation.

These direct environmental impacts have resulted from poor and unsustainable wastewater sludge management practices and the impacted land will require rehabilitation.

Determining the opportunity cost of not being able to utilise land that has been used for sludge drying or dumping is difficult and was deemed not within the scope of this study.

The most direct way to determine the impact that poor sludge management practices have had on these tracts of land was to ascertain rehabilitation costs. The table below outlines the costs associated with the total rehabilitation of land that has been utilised for sludge disposal. Once rehabilitated, this land will be suitable for human habitation.

Land Rehabilitation Costs		
Area	**Cost / Square Meter**	**Total Cost**
1 hectare	R150	R1 500 000
	R300	R3 000 000
5 hectare	R150	R7 500 000
	R300	R15 000 000

From the above table it is clear that the rehabilitation of impacted land is very costly. An area of only 1 hectare can cost as much as R1 500 000 to rehabilitate before it is suitable for human habitation; rehabilitation of larger tracts of land is significantly more expensive as outlined above.

These rehabilitation costs add a significant amount to the cost of land utilisation, which will in some cases render the land useless.

This example outlines the negative impacts that can result from poor wastewater sludge management and disposal; the cost to rehabilitate land is high and can result in tracts of land being uninhabitable. Volume 3 of the WRC's Sludge Guidelines aim to mitigate any potential impacts that may result from poor sludge disposal practices and hereby avoid the potential cost of land rehabilitation.

Groundwater Contamination

The Tshwane Municipality has experienced an ongoing struggle with wastewater sludge groundwater contamination. The 10 wastewater treatment works that serve the City of Tshwane have dedicated tracts of land for disposal of wastewater sludge, which equate to an area of more than 100 hectares. The continued disposal of sludge on these areas over the years has resulted in a build-up of particular nutrients and contaminants that have leached into the local groundwater.

In 2002, Africon Civil and Environmental Engineers were appointed by the Tshwane Metropolitan Municipality to conduct an investigation to determine the impact of waste handling facilities on the groundwater at various wastewater treatment facilities in the area. Ten different wastewater treatment facilities were monitored for a period of 4 years and groundwater at 7 out of the 10 sites were found to be contaminated.

The results of the investigation showed that:

- Sludge disposal at Babalegi and Sunderland wastewater treatment works showed signs of groundwater contamination based on the monitoring results of the last 4 years.
- Sludge disposal at 5 sites: Baviaanspoort, Klipgat, Rooiwal, Temba and Zeekoegat wastewater treatment works show serious signs of groundwater pollution based on the monitoring results of the past four years.

The remediation of these sites will be very expensive and unless the land is developed it will probably not be economically feasible.

The 2006 Sludge Guidelines offer Tshwane wastewater treatment works a feasible solution to this environmental problem. If sludge can be utilised for alternative applications such as fertilising, brick or cement manufacture then this environmental impact could be curbed in the future.

4. Conclusions

Wastewater sludge management in South Africa has been governed through a series of wastewater sludge guidelines over the previous three decades. Each of these guidelines has aimed to assist stakeholders with management aspects of wastewater sludge handling. The 2006 Sludge Guidelines were released to address previous sludge guideline shortcomings and provide an easy-to-use management tool for all handling of wastewater sludge.

The aim of this project was to quantify the potential impact that the 2006 Sludge Guidelines could have on South African society. The project focused on analysing examples of wastewater sludge management best practise that already comply with the principles of the 2006 Sludge Guidelines. Numerous examples were identified and the implications for South Africa were reviewed.

The potential impacts of the 2006 Sludge Guidelines identified during this project have been outlined in the table below:

IMPACT AREA		IMPACT
ECONOMIC	**Land Application**	Soil remediation
		Farming (nutrient source)
	Thermal Use	Incinerator fuel
	Landfill Cover	Cover for landfills
		Mining waste rehabilitation
	Construction Materials	Cement, bricks
		Pumice, artificial aggregate
	Fertilisers	Raw material for compost
		Raw material for dry pellets
SOCIAL	**Worker**	Job Creation Management staff
		Job Creation Truck drivers
		Job Creation Labourers
	General Public	Reduced Smells
		Reduced Fly Attraction
ENVIRONMENTAL	**Land Use**	Contamination
		Opportunity Cost
	Leaching	Contamination of Groundwater
	Run-off	Contamination of Surface water

Each focus area, namely economy, society and environment, will potentially be impacted in a different way if fulfillment of the 2006 Sludge Guidelines is achieved.

With regard to economic impact, a selection of organisations that benefit directly from the re-use of wastewater sludge were assessed. Revenue generation and cost savings are afforded to brick

and fertiliser manufacturers, farmers through agricultural use and disposal savings for municipalities. Each of the organisations reviewed benefit as a result of wastewater sludge handling that is aligned with 2006 Sludge Guidelines and if these guidelines were implemented throughout South Africa the economic impact would be significant.

Social impacts were quantified in the form of assessing job creation as a result of utilising wastewater sludge as outlined in the 2006 Sludge Guidelines. Of the companies analysed, numerous jobs were created and employees benefited directly through remuneration. Smell and fly nuisance impacts were more qualitative in nature and difficult to quantify, however the 2006 Sludge Guidelines are focused on reducing these social effects. South Africa is challenged with high unemployment levels and if the 2006 Sludge Guidelines are implemented effectively, numerous jobs could be created through the re-use of wastewater sludge.

Poor handling and mismanagement of wastewater sludge, which has stemmed from limitations within previous wastewater sludge guidelines, has resulted in numerous incidences of wastewater sludge dumping on uninhabited land. Land that has been used for dumping is not habitable and requires expensive rehabilitation. Incidences of groundwater contamination have also been recorded as a result of poor wastewater sludge handling. The 2006 Sludge Guidelines outline wastewater sludge handling practices that are focused on the sustainable use of land and until these guidelines are implemented effectively, contamination events and poor land utilisation will continue.

The examples identified during the completion of this project clearly reflect that wastewater sludge management practices that are aligned with the 2006 Sludge Guidelines have a significant impact across economic, social and environmental areas of South African society. Effective implementation of the 2006 Sludge Guidelines is required, and once this is achieved, the impacts detailed above will almost certainly be realised.

5. Appendices

Appendix 1

No.	Year	Code	Research Report Title	Author(s)
1	1992	TT 55	Anaerobic Digestion of Wastewater Sludge - Operating Guide	Ross WR; Novella PH; Pitt AJ; Lund P; Thomson BA; King PB; Fawcett KS
2	1997	TT 85	Permissable Utilisation and Disposal of Sewage Sludge	Department of Water Affairs and Forestry,; Department of Agriculture; Water Institute of Southern Africa; Department of Health; Water Research Commission
3	1999	TT 107	Guidelines for the design and operation of sewage sludge drying beds	Ceronio AD; Van Vuuren LRJ; Warner APC
4	2002	TT 154	Permissable Utilisation and Disposal of Sewage Sludge: Addendum No 1 to Edition 1 (1997)	Water Research Commission; Department of Water Affairs and Forestry; Department of Agriculture; Department of Health with the assistance of Sludge Consult
5	2006	TT 261	Guidelines for the utilisation and disposal of wastewater sludge: Volume 1 of 5: Selection of Management Options	Snyman HG; Herselman JE; Golder Associates Africa
6	2006	TT 262	Guidelines for the utilisation and disposal of wastewater sludge: Volume 2 of 5: Requirements for the agricultural use of wastewater sludge	Snyman HG; Herselman JE; Golder Associates Africa

No.	Year	Code	Research Report Title	Author(s)
7	1984	TT 16	Theory, design and operation of nutrient removal activated sludge processes	University of Cape
8	1984	87	Sludge stabilisation and disinfection by means of autothermal aerobic digestion using oxygen	Trim BC
9	1990	327	Evaluation of the active sewage pasteurisation (ASP) process for the treatment of sewage sludge	Nell JH; Van der Merwe M; Barnard RO
10	1992	189	Evaluation and optimisation of dual digestion of sewage sludge. Executive Summary	Division of Water Technology CSIR; Milnerton Municipality; University of Cape Town; Afrox Ltd
11	1992	189	Evaluation and optimisation of dual digestion of sewage sludge. Part 1: Overall system performance	De Villiers HA; Messenger JR; Kenmuir K; Laubscher SJA; Ekama GA
12	1992	189	Evaluation and optimisation of dual digestion of sewage sludge. Part 2: Aerobic reactor performance	Messenger JR; Ekama GA; De Villiers HA; Kenmuir K; Laubscher SJA

13	1992	189	Evaluation and optimisation of dual digestion of sewage sludge. Part 3: Evaluation of the technology for practical implementation	Laubscher SJA; Kenmuir K; De Villiers HA; Messenger JR; Ekama GA
14	1993	249	Pelletization in upflow anaerobic sludge bed (UASB) systems	Moosbrugger RE; Sam-Soonn PALNS; Wentzel MC
15	1995	427	Development of electro-osmotic sludge dewatering technology	Smollen M; Kafaar A
16	1997	316	Aspects of sewage sludge handling and disposal	Lotter LH; Pitman AR
17	1997	688	Laboratory and pilot-plant bioreactor development for remediation of metal-contaminated wastewater using activated sludge as biosorbent	Bux F; Atkinson BW; Kasan HC
18	1998	776	Fingerprinting of activated sludge systems using PAGE analysis of total protein extractions for the optimization of biological phosphorus removal	Ehlers MM; Erasmus A; Cloete TE
19	1998	241	Research on the filtration of compressible cakes	Pillay VL
20	1999	559	Co-disposal and composting of septic tank and pit latrine sludges with municipal reuse	Pearson I; La Trobe B
21	2001	1339	Survey and methodology for analysing organic pollutants in South African sewage sludge	Water Research Commission 2001 Work Group
22	2004	1240	A technical and financial review of sludge treatment technologies	Marx CJ; Alexander WV; Johannes WG; Steinbach-Kane S
23	2004	1210	Laboratory and field scale evaluation of agricultural use of sewage sludge.	Snyman HG; van der Waals JH
24	2004	1172	The evaluation and design of sludge dewatering and water filtration systems using tubular woven fabric technology	Rajagopaul R; Pillay VL
25	2004	1170	Investigation into the enzymology of accelerated primary sewage sludge solubilisation and digestion in sulphate reducing systems	Whiteley CG; Pletschke BI; Burgess JE; Tshivhunge AS; Ngesi N; Whittington-Jones K; Enongene G; van Jaarsveld F; Heron P; Rashamuse; Rose PD
26	2004	762	Anaerobic digestion of high-strength or toxic organic effluents in available digester capacity	Sacks J; Buckley CA
27	2004	1283	A metal content survey of South African sewage sludge and an evaluation of analytical methods for their determination in sludge	Snyman HG: Herselman JE; Kasselman G
28	2005	1209	An evaluation of dedicated land disposal practices for sewage sludge.	Herselman JE; Wade PW; Steyn CE; Snyman HG
29	2005	1216	Hydrolysis of primary sewage sludge under methanogenic, acidogenic and sulfate-reducing conditions,	Ristow NE; Soteman SW; Loewenthal RE; Wentzel MC; Ekama GA
30	2006	1453	Premise for the development of volume 1 and 2 of the South African sludge guidelines.	Snyman HG; Herselman JE; Golder Associates Africa