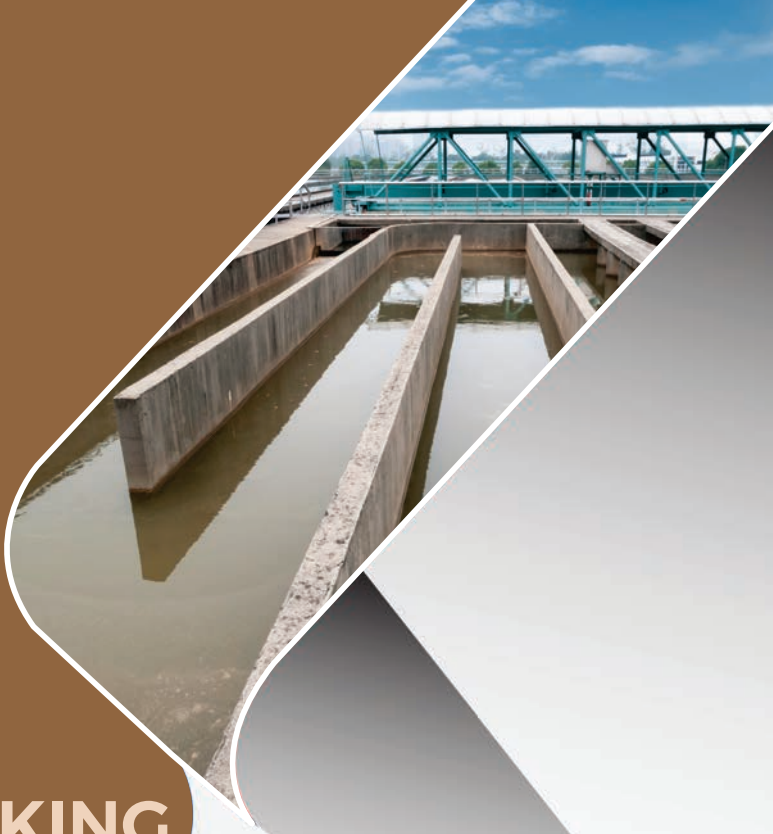

RETHINKING
Wastewater Sludge

WATER RESEARCH COMMISSION

Obtainable from:
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CONTENTS

INTRODUCTION

Wastewater sludge refers to the solid, semi-solid or liquid residue generated during the treatment of domestic sewage in a treatment works. The management of sludge is the responsibility of local authorities.

Historically, when sewage treatment plants were located on the outskirts of urban areas, sludge was either dumped in the precinct of the treatment facility or on land adjacent to the facility. However, with increasing population levels and high urbanisation rates cities and towns have expanded and encroached on these facilities as land has become increasingly scarce. This fact, along with increasing international trends to view sludge as a resource rather than a waste material, have underlined the importance of finding new, safer ways, of managing wastewater sludge sustainably.

Sludge management is critical when it comes to ensuring compliance and reducing operational risks at a wastewater treatment plant. Mismanaged sludge can have a considerable negative impact on the environment and human health.

This publication aims to provide a brief overview of options for handling wastewater sludge produced during the wastewater treatment process in South Africa. It is intended for anyone with a responsibility for addressing wastewater sludge, particularly decision-makers.

The publication provides an overview of:

1. Why it is important to manage wastewater sludge
2. What options are available for dealing with wastewater sludge
3. What we know about the costs of dealing with wastewater sludge, based on conducted case studies

Following these sections, the publication provides some guidance and tools for budgeting for managing wastewater sludge. While the information provided in this guide will not be directly applicable to each individual situation, it effectively provides ranges that can be used for budgeting purposes before detailed costing. For municipalities looking for a different option, this information can help with decision-making. If wastewater sludge management has not been planned for in the past, this provides a starting point.

WHY IS WASTEWATER SLUDGE MANAGEMENT IMPORTANT?

Managing wastewater sludge is important for several reasons, including:

1. **Protect** public and environmental health – Mismanaged wastewater sludge can pollute the environment, putting the public at risk of exposure to pathogens. Large stockpiles of sludge can be washed into nearby watercourses.

2. **Comply** with legislation – By the time the current version of the *Sludge Guidelines* was published in 2006, the Department of Water and Sanitation (DWS) had already stated that indefinite storage of sludge, or "stockpiling" would no longer be acceptable. However, nearly a decade later, stockpiling of sludge at wastewater treatment plants (WWTPs) is still a common practice. Furthermore, stockpiling is not controlled and designed as required in the minimum requirements for waste disposal under the National Environmental Management: Waste Act (Act no 59 of 2008) (NEMWA). Because sludge is a resource that has potential to pollute the environment, it requires active management.

3. **Achieve** Green Drop status – The 2022 Green Drop report states that poor sludge management practices have an overall negative impact on overall treatment capability. This is critical to compliance and in reaching Green Drop status. Sludge handling is included in several aspects of the Green Drop auditing process. Therefore, sludge handling can be a limiting step in achieving full Green Drop status. By taking simple steps now, such as classifying wastewater sludge, plants can begin to positively impact their Green Drop score.

4. **Uncover** the untapped potential of beneficiated sludge

WHAT OPTIONS ARE THERE FOR MANAGING WASTEWATER SLUDGE?

The general options for managing wastewater sludge are summarised in Volume 1 of the ***Sludge Guidelines*** (see Resources page). These options include:

1. Agricultural use at agronomic rates (Volume 2)
2. On-site or off-site disposal (Volume 3)
    - On-site (monofil – which refers to a landfill specifically designed and used for the disposal of only one type of waste byproduct, such as sewage sludge; waste piles; lagoons)
    - Dedicated land disposal

- Co-disposal in general landfill
- Co-disposal in hazardous landfill

3. Beneficial use (other than agricultural use at agronomic rates) (Volume 4)
    - Once-off high rate sludge application
    - Continuous high-rate application for edible or industrial crops
    - General landfill cover material
    - Hazardous landfill cover material
4. Thermal treatment (Volume 5)
5. Commercial products (Volume 5)
    - Fertiliser products
    - Other commercial products (e.g., bricks)

The selected option for managing wastewater sludge will depend primarily on the sludge classification in terms of microbiological, stability, and pollutant classification. Table 9 (page 24) shows all possible classifications for sludge and the appropriate options covered by the ***Sludge Guidelines***. In addition to considering sludge quality, the choice of sludge disposal or beneficial use will depend on land availability, costs, demand for beneficiated products, and the waste hierarchy. According to the waste hierarchy, disposal should be the last resort, and options for recycling and beneficial use should be prioritised. This is in line with the move towards wastewater sludge as a resource, rather than a liability.

WHAT DO WE KNOW ABOUT THE COSTS?

The cost of disposing or beneficially using sludge produced in WWTPs depends on several different factors. In this study, six (6) different case studies provided data on the costs of wastewater sludge disposal. The case studies and data provided are described below.

Table 1: Summary of case studies with cost data on WW sludge disposal/beneficial use

Study no.	Approach description	Compliance	Transport	Treatment	Disposal/ Beneficial Use	Data provided
1a	Agricultural application of waste activated sludge in sugarcane fields in line with Volume 2 of the sludge guidelines	✓	✓		✓	Contractor rates per cubic metre for management (incl. classification), transport, and disposal
1b	Agricultural application of digested sludge in sugarcane fields in line with Volume 2 of the sludge guidelines	✓	✓		✓	Contractor rates per cubic metre for management (incl. classification), transport, and disposal
2	Disposal of sludge in hazardous landfill		✓	✓	✓	Contractor rates per cubic metre from contract
3a	Transport of digested sludge to farms an average of 50km away		✓			Rates per cubic metre for transport – costs exclude management tasks done by the WSA and application
3b	Composting of sludge, with product collected by farmers			✓		Treatment cost only for composting, reported by WSP

Study no.	Approach description	Compliance	Transport	Treatment	Disposal/ Beneficial Use	Data provided
3c	Composting of sludge, with product delivered to farmers		✓	✓		Treatment + transport costs, reported by WSP
4	Production of commercial product by private partner					No cost to the municipality – all costs (and income) borne by the private party
6	Continuous high-rate application of sludge with industrial crops					No cost data provided – but costs are borne by the private party except for compliance
7	Transport of dried sludge from small WWTPs to central site for further drying and land application/ treatment		✓			Transport costs only (transport in 10-ton trucks)
8	Transport and application of dried sludge in agriculture	✓	✓			Municipality's costs for classification Contractor's rate for transport, inclusive of all work necessary to comply with guidelines (e.g., proper disposal)

Costs of wastewater sludge disposal/beneficiation

The case studies described above generally present five different approaches to wastewater sludge management, namely:

1. **Agricultural application**: Transporting sludge from the WWTPs to farms for land application as per the ***Sludge Guidelines***.

2. **Solar drying/composting and delivery to farms**: Treating sludge from the WWTP further through a solar drying and composting process in order to produce an A1a product,

as per the ***Sludge Guidelines***. The present situation is that sludge is delivered to farms, rather than being sold, as supply exceeds demand. For comparison purposes, the option of composted sludge being collected by farmers is also presented below.

3. **Continuous high-rate application of sludge for industrial crops**: In this arrangement, digested sludge is pumped directly to sludge disposal lands where turf grass is grown. The turf grass operation is run by a private company that pays a fee to use the municipal land, and they keep all income generated through the sale of turf grass. The water service authority (WSA) owns the infrastructure and maintains it. It also covers all necessary monitoring, including, for example, sludge classification, soil monitoring, and groundwater monitoring. The actual costs for these were not provided to the researchers.

4. **Production of a commercial product by a private company**: In this arrangement, sludge from the WWTP is given (or sold) to a private company for further treatment and beneficiation. In this case, the private company pays a fee to the municipality (for example, 'buying' the sludge or land rental fee). The costs of further treatment, beneficiation, marketing, and packaging all fall on the private company, and no further costs are incurred by the municipality.

5. **Hazardous landfill disposal**: Transporting sludge from the WWTP to a hazardous landfill for safe disposal. The cost includes the gate fee, treatment to immobilise heavy metals, and disposal in trenches. This is one of few options for sludge with a "c" pollutant classification, as per the ***Sludge Guidelines*** (see Table 9 for more options).

The costs for these five approaches are summarised in Figure 1, highlighting the cost to the municipality). These costs exclude 'compliance' costs related to, among others, sludge classification. The costs indicate that partnerships with private companies with an interest in sludge beneficiation can lead to considerable savings. The most cost-effective option outside of this is the application of sludge to agricultural land, if sufficient land is available and close enough (for example, less than 50 km travel distance), and that sludge classification is appropriate for this approach (***Sludge Guidelines Volume 4).***

The specific reported costs for the different aspects of the sludge service chain are summarised in the sections below.

SUSANA

Sewage sludge being applied to agricultural land.

SUSANA

A typical vehicle used for liquid sludge application

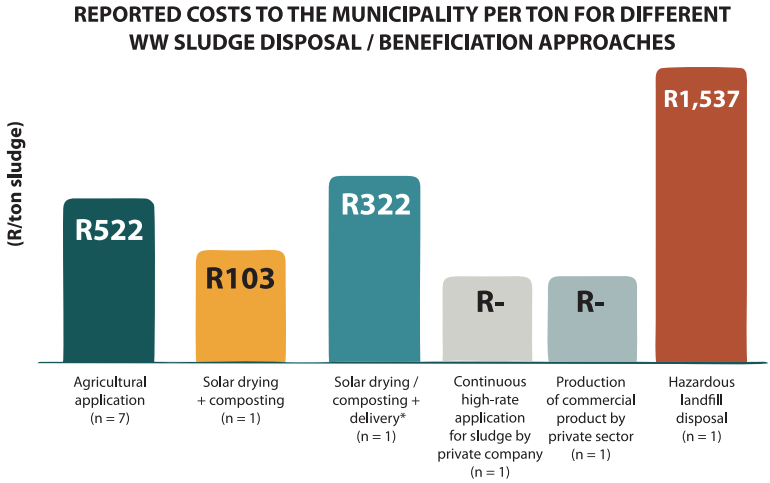


Figure 1: Reported cost of WW sludge management options (R/ton[1] sludge processed) for different approaches across case studies (all costs adjusted to May 2024 rates, excluding compliance)

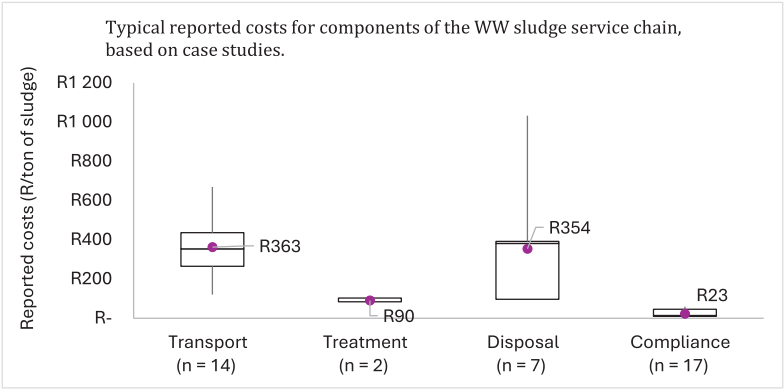


Figure 2: Average costs of sludge disposal/beneficiation, reported in case studies

[1] Note that the density of sludge is generally approximately 1.1t/m³ so tons and cubic metres are often used interchangeably in general discussions about sludge handling costs. In the calculations in this resource, a density of 1t/m³ has been assumed. For a specific situation where costs and budgets are being calculated, the actual density for the sludge in question should be measured and used in the calculations.

Table 2: Cost ranges from case studies for different aspects of sludge disposal/ beneficiation

	Typical range (R/ton)	Median (R/ton)	Average (R/ton)
Transport	R 246 – R 421	R 336	R 350 (± R138)
Treatment	R 61 – R 103	R 103	R 89 (± R24)
Disposal	R 89 – R 1 033	R 382	R 349 (± R335)
Compliance	R 0.45 – R 59	R 14	R 23 (± R22)
OVERALL	R 0.45 – R 1 514	R 426	R 470 (± R354)

The different aspects of the sludge management service chain are discussed in detail below. This excludes the conventional treatment of wastewater sludge at WWTPs, which was excluded from this study. Breaking the process into these distinct parts assists with considering different combinations of approaches outside of the ones covered by this study.

Transport

Sludge may be transported for different reasons, including to a centralised treatment/ beneficiation facility, for application in agriculture, or disposal in a landfill. In this study, 14 data points were provided for transport of sludge[2]. The average rate for transport of sludge is R336 per ton, with a range from R112 to R669 per ton. The main factors that impact the cost of transporting sludge are distance and size of vehicle.

DISTANCE

The distances from WWTP to destination in this study ranged from 20km to 74km, and the cost per ton over distance ranged from R2.23/ton/km to R20.33/ton/km, with an average of R7.63/ ton/km. The wide range highlights the fact that there was not a strong correlation between distance and cost. The data provided suggests that at distances greater than 50km, the rate per ton for transport would likely increase.

SIZE OF VEHICLE

Various vehicles were used to transport sludge in the case studies, including 7m^3 skips, 10-ton dump trucks, 18m^3 side tippers, and 30 m^3 side tippers. Larger vehicles, while heavier on fuel, will

[2] Note that some case studies provided several different rates for transport.

also make transport more efficient, reducing the number of trips to a minimum. This is consistent with decreasing rates for transport as larger vehicles were used.

WHAT CAN MAKE TRANSPORT MORE EFFICIENT?

The best way to reduce the cost of transport is to reduce the amount of sludge being transported. By reducing the weight and volume of sludge, the total cost will decrease, though the volumetric rate for transport will remain the same. Volume and weight reduction is primarily done by drying sludge.

Three truckloads of 30 tonnes of wet sludge will be reduced to 1 truckload after you've dried it… when we transport…we are trying to avoid transporting more [wet than dry]… [transporting 80% water is] not feasible [or] profitable for the company.

– Sludge Manager at a Water Service Provider (WSP) for a Metro Municipality

Advanced treatment

Advanced treatment refers to treatment beyond typical WWTP processes (e.g., anaerobic digestion, dewatering, drying). This may include composting, heat treatment, addition of chemicals, extended drying, or other processes. The benefits of treatment include:

- Reduction in sludge volume and weight
- Improvements to final product.

This is typically done if the aim is to produce a product that can be safely used by the public and even sold for a profit (i.e., an A1a product), but it may also be done to make sludge safer for disposal. In this study, three case studies included treatment of sludge beyond the general WWTP process:

1. Addition of lime before disposal in a hazardous landfill, as per Volume 3 of the ***Sludge Guidelines***. This applies to sludge in pollutant class b and c to immobilise contaminants. (Case Study 2).
2. Solar drying and composting of digested sludge to produce an A1a product (without addition of a bulking agent) which is ideally collected by farmers but is occasionally delivered to them if sludge begins to pile up. This is done by the Water Services Provider (WSP) of a metro municipality, which has a dedicated "Sludge Manager" who can oversee the research and development of this process. (Case study 3).
3. Extended drying and granulation of sludge, followed by blending with commercial fertiliser to meet farmers' needs. This is done by a private business that pays the municipality for the dry sludge it receives from them. The unique arrangement, which does not cost the municipality anything, is based on a 15-year contract which was competitively adjudicated. (Case study 4).

Treated and dried sludge pellets, which can be sold as fertilizer.

Costs to the municipality/WSP for the above three processes are provided below.

Table 3: Reported costs for further treatment of WW sludge

Description	Cost to municipality (R/ton)	Case study ref.
Lime addition for landfill disposal	R 61	2
Solar drying and composting without bulking agent	R 103	3
Extended drying, granulation, and blending with commercial fertiliser	R 0*	4

In this case, the private company pays the municipality for the sludge supplied and there is **no cost to the municipality.*

While the arrangement in Case Study 4 leads to no income for the municipality from the fertiliser, it also incurs no costs, while limiting the risk to the municipality. The private business is motivated to maintain their processes and produce a product that is authorised and saleable, taking on the burden of compliance with the sludge guidelines as well as agricultural legislation.

Disposal

WW sludge disposal in this case covers both the discarding of wastewater sludge and application in agriculture, in line with the ***Sludge Guidelines***. The cost of wastewater sludge disposal is primarily determined by the method used to dispose of sludge, which may require extensive labour or specific machinery. The safe method of sludge disposal is also determined by the sludge classification and characteristics. In this study, three instances of wastewater sludge disposal were included, with costs ranging from R89/ton up to R1 033/ton. The three instances are summarised below.

Table 4: Reported costs of WW sludge disposal from 3 case studies

Description	Cost to municipality (R/ton)	Case study ref.	Note(s) on costs
Application of waste activated sludge to sugarcane fields	R382	1	The instability of WAS requires that it be incorporated into the soil, rather than applied on top. This ensures vector control and requires special equipment and timeous land application.
Application of digested sludge to sugarcane fields	R89	1	Due to better stability class than WAS, sludge can be applied and spread on the surface, making the process simpler.
Disposal in hazardous landfill	R1 033	2	Costs include gate fees as well as the cost of trenching and burying the sludge.

Disposal in a hazardous landfill is limited by legislation and not sustainable due to finite space in landfills. As shown above, it also comes with a high cost primarily due to gate fees. Disposal in agricultural fields or commercial forests is both cheaper and provides some benefit to the environment, provided the sludge does not have high levels of industrial pollution.

Compliance

Compliance costs, not included in the overall costs above, vary based on the selected sludge disposal/beneficial use method and the dry tons of sludge produced per year. Only one case study provided costs and frequency of sludge classification, whereas the others did provide specific detail. Therefore, the researchers have used the ***Sludge Guidelines*** along with cost estimates to determine estimated costs for compliance. The compliance and monitoring requirements for each approach are presented in Table 5, based on the relevant volume in the ***Sludge Guidelines***. The costs of these activities are approximated below.

Table 5: Monitoring requirements for different sludge disposal/beneficial use approaches

Option	Guidelines Volume	Sludge	Soil	GW	Surface Water	SANS[3]
Application in agriculture	2	Y	R	N	N	N
Commercial products	5	Y	N	N	N	Y
Continuous high-rate application	4	Y	Y	Y	Y	N
Landfill disposal	3	Y	N	N	N	N

Y = Yes, required; R = recommended; N = Not required

[3] SANS classification is based on the specific commercial product being produced. Determination of these requirements and costs is outside the scope of this report.

The costs of compliance activities were estimated based on rates sourced from South African labs providing these services. The costs utilised in the estimates are shown below.

Table 6: Reported costs for monitoring

Monitoring	Description	Total cost[4]
Sludge classification	3 samples, as per ***Sludge Guidelines***	R12 000
Soil monitoring	3 samples, nutrients, metals, and soil pH	R2 310
Water monitoring (surface or ground)	2 samples, chemistry, microbiology	R3 000

The frequency of required monitoring for each of the above is described in the relevant volume of the ***Sludge Guidelines***. Importantly, the frequency of sludge classification depends on the dry tons of sludge produced each year. Using the above costs and the requirements provided in the ***Sludge Guidelines***, the cost for compliance in the case studies included ranged from R0.45/ton to R59/ton, with an average of R23/ton.

Table 7 below shows the estimated compliance costs in rands per dry ton of sludge for the different options presented here. For most approaches, the cost per dry ton differs based on the quantity of sludge handled, because the monitoring frequency required in the ***Sludge Guidelines*** depends on the dry tons of sludge.

Agricultural application at agronomic rates requires considerable additional work to ensure compliance with the guidelines. Case study 1, which covered this approach in detail, reported rates for "management" ranging from R41 per cubic metre to R165 per cubic metre or R38/ton to R153/ton, respectively. In addition to sludge classification costs, these rates included identification of appropriate farms, liaison with farmers, and ensuring compliance during the sludge application process.

[4] These cost estimates are based on quotes provided by suppliers. Note the suppliers' names have been kept confidential.

Table 7: Approximate compliance costs (R/dry ton sludge) for sludge disposal/beneficial use options, based on the *Sludge Guidelines*

Sludge quantity	Agricultural application	Commercial product	High-rate continuous application	Landfill disposal
<365 dt/yr	R88.68	R293.21	R2 481.25	R83.33
365 – 1 825 dt/yr	R68.09	R293.21	R227.38	R66.67
1 825 - 16 500 dt/yr	R18.40	R293.21	R31.23	R17.50
>16 500 dt/yr	R5.78	R293.21	R11.49	R5.00

HOW CAN ONE BUDGET FOR WASTEWATER SLUDGE MANAGEMENT?

How does one start to budget for sludge management, given the varied costs and the different approaches taken? This question is difficult to answer, especially given the reality that no two treatment plants are the same. Influent quality, wastewater and sludge treatment processes, operation, and climate all influence the quantity and quality of sludge that needs to be handled and therefore the cost of managing it.

Ideally, the end-use of sludge should be selected up front, based on economic and environmental analysis and assessment of the demand for beneficiated sludge products. In this case, sludge treatment would be designed based on the desired end-use. However, the reality in existing South African WWTPs is that there is a need to urgently find a way to manage the sludge that is already being produced.

Budgeting for sludge disposal or beneficial use firstly requires an understanding which options are possible and permissible within the ***Sludge Guidelines***. So, the first step is classification.

1. **Classify the sludge:** If this has not been done yet, comprehensive sludge characterisation should be carried out on three samples from ***every stream*** of sludge that requires disposal. One estimate from a laboratory indicated that this would cost approximately R15 000 per sludge stream. Refer to Volume 1 of the ***Sludge Guidelines*** for more detail.

Based on the microbial, stability, and pollutant classification, determine the which options are possible.

2. **Identify possible options for sludge disposal**: Table 9 and Table 10 summarise the options presented in the ***Sludge Guidelines*** and whether they are possible/permissible based on the sludge classification.
3. **Determine the approximate cost for different options**: Data from this study has been used to produce general estimates for the cost of different approaches to sludge disposal/beneficial use. While the above section presents costs per ton of sludge, the budgeting figures in Table 8 below provide a cost per megalitre of wastewater treated, as this can be more useful for budgeting, particularly if sludge production is not well understood. The estimates assume typical sludge production of 1.7 m^3 sludge per Mℓ WW treated[5]. The costs will change based on the actual sludge production, which depends on several factors including influent characteristics and treatment processes. These costs highlight that enhancing sludge drying/dewatering can decrease costs. The next section of this report presents a tool that can provide more detailed estimates for the different methods.

Table 8: Typical sludge disposal/beneficiation costs for different approaches, assuming different dryness levels of sludge (costs based on data provided in this study)

Disposal Options with cost data	Typical sludge disposal/beneficiation cost (R/Mℓ WW treated)		
	4% TS	20% TS	40% TS
Agricultural application of digested sludge	N/A	R 1 220	R610
Solar Drying and Composting (delivered)	N/A	R720	R360
Solar Drying and Composting (collected)	N/A	R300	R150
High-rate continuous application on industrial crops (PPP)	R4.30	R0.90	R0.50
Production of commercial agriculture product (PPP)	N/A	R2.00	R1.00
Hazardous landfill disposal	N/A	R2 730	R1 370

Investments upstream in sludge treatment facilities can decrease disposal costs. And they can open the door to more downstream disposal/beneficial use options.

[5] Source: von Sperling, M. (2007). ***Biological Wastewater Treatment Series (Volume 1). Wastewater Characteristics, Treatment and Disposal.*** Table 5.2, pp. 250.

4. **Consider ways to improve sludge quality**: As shown in the sludge classification and options tables, changing the sludge classification can open new opportunities for sludge disposal or beneficiation. Microbiological and stability classification can be improved through various treatment methods:
    - Improve anaerobic digester operation to improve stability
    - Solar drying and/or composting to improve both

Pollutant classification is more difficult to improve. If there are challenges with heavy metals in sludge, implement source control for wastewater coming into the WWTP by preventing illegal discharge by industries and stormwater ingress. Sludge treatment methods to remove metals are generally not cost-effective. If heavy metals are high, consider beneficiation technologies that produce products not used in agriculture.

A TOOL FOR ESTIMATING SLUDGE DISPOSAL/BENEFICIATION COSTS

The ***WW Sludge Options*** MS excel spreadsheet has been prepared to assist with budgeting and comparison of different options. Specifically, the following options are included in the spreadsheet, as these were covered by case studies in this project:

1. Agricultural application of sludge at agronomic rates
2. Solar drying and composting (delivered or collected from the WWTP)
3. High-rate continuous application on industrial crops (partnership with private company)
4. Production of commercial agricultural product (partnership with private company)
5. Hazardous landfill disposal

The user is prompted to enter the following information:

- Wastewater treated (Mℓ/day) [required]
- Sludge characteristics:
    - Classification [optional]
    - % total solids [required]
    - Production (m^3/day) [optional]

Enter data about your WWTP and sludge production:

WW treated (ML/day)	50
Sludge characteristics	
Classification	B2a
%TS	20%
m^3/day (actual)	80

As noted above, certain characteristics are required for the calculations and others are optional.

The image above shows an example of data entered. If the quantity of sludge produced is not known, a range is suggested.

Based on the above, the tool calculates a range of cubic metres of sludge produced each day based on guidance from von Sperling (2007). This includes a 'low' sludge production, 'mid' or average sludge production, and 'high' sludge production. If the actual sludge production was entered above, this is also included. Based on the percentage total solids (TS), the dry tons of sludge per year are calculated, which is important for determining the monitoring/compliance requirements. The sample output is shown below.

Estimated sludge production	m^3/day	dry tons per year
Low production	74.2	5 418
Mid production	85.9	6 273
High production	97.7	7129
Actual	80.0	5 840

Based on the data entered and the calculated sludge quantities, the five different disposal options are summarised. This includes an assessment of whether the option is applicable based on the classification and a range of costs for transport, treatment, disposal, and compliance/ management. Again, costs are presented in units of rands per megalitre of wastewater treated, to support budgeting. The sample output is shown in Figure 3.

In addition to the summary table, two additional figures are generated, including one showing R/Mℓ treated for each sludge production level, and one showing an annual cost estimate for each.

Table 9: Sludge classification and appropriateness for approaches in Volume 2 and 3 of the Sludge Guidelines

Classification	Agricultural use at agronomic rates (Volume 2)	On-site (monofill, waste piles, lagoons)
A1a	Yes	Qualified no
A2a	Qualified yes	Qualified no
A3a	No	Qualified no
A1b	Qualified yes	Maybe
A2b	Qualified yes	No
A3b	No	Qualified no
A1c	No	No
A2c	No	No
A3c	No	No
B1a	Qualified yes	Qualified no
B1b	Qualified yes	No
B1c	No	No
B2a	Qualified yes	Maybe
B2b	Qualified yes	No
B2c	No	No
B3a	No	Qualified no
B3b	No	Qualified no
B3c	No	Qualified no
C1a	Qualified yes	Qualified no
C1b	Qualified yes	Maybe
C1c	No	No
C2a	Qualified yes	Qualified no
C2b	Qualified yes	No
C2c	No	No
C3a	No	Qualified no
C3b	No	No
C3c	No	No

On-site or off-site disposal (Volume 3)		
Dedicated land disposal (DLD)	Co-disposal in general landfill	Co-disposal in hazardous landfill
Qualified no	Qualified no	Qualified no
Qualified no	Qualified no	Qualified no
Qualified no	Qualified no	Qualified no
Maybe	Maybe	Maybe
No	No	Qualified yes
Qualified no	Qualified no	Qualified no
No	No	Qualified yes
No	No	Qualified yes
No	No	Qualified no
Qualified no	Qualified no	Qualified no
No	No	Qualified yes
No	No	Qualified yes
Maybe	Maybe	Maybe
No	No	Qualified yes
No	No	Maybe
Qualified no	Qualified no	Qualified no
Qualified no	Qualified no	Qualified no
Qualified no	Qualified no	Qualified no
Qualified no	Qualified no	Qualified no
Maybe	Maybe	Yes
No	No	Qualified yes
Qualified no	Qualified no	Qualified no
No	No	Qualified yes
No	No	Qualified yes
Qualified no	Qualified no	Qualified no
No	No	Qualified yes
No	No	Qualified yes

Table 10: Sludge classification and appropriateness for approaches in Volume 4 and 5 of the Sludge Guidelines

Classification	Beneficial use (other than agricultural use at agronomic rates) (Volume 4)		
	Once-off high rate sludge application	Continuous high-rate application - Edible crops	Continuous high-rate application - Industrial crops
A1a	Yes	Yes	Yes
A2a	Qualified yes	Qualified yes	Qualified yes
A3a	No	No	No
A1b	Qualified yes	Qualified yes	Qualified yes
A2b	Qualified yes	Qualified yes	Qualified yes
A3b	No	No	No
A1c	Qualified yes	No	Qualified yes
A2c	Qualified yes	No	Qualified yes
A3c	No	No	No
B1a	Qualified yes	Qualified yes	Qualified yes
B1b	Qualified yes	Qualified yes	Qualified yes
B1c	Qualified yes	No	Qualified yes
B2a	Qualified yes	Qualified yes	Qualified yes
B2b	Qualified yes	Qualified yes	Qualified yes
B2c	Qualified yes	No	Qualified yes
B3a	No	No	No
B3b	No	No	No
B3c	No	No	No
C1a	Qualified yes	No	Qualified yes
C1b	Qualified yes	No	Qualified yes
C1c	Qualified yes	No	Qualified yes
C2a	Qualified yes	No	Qualified yes
C2b	Qualified yes	No	Qualified yes
C2c	Qualified yes	No	Qualified yes
C3a	No	No	No
C3b	No	No	No
C3c	No	No	No

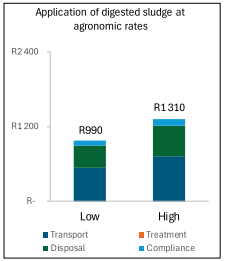
		Commercial products (Volume 5)		
General landfill cover material	Hazardous landfill cover material	Thermal treatment methods	Fertiliser products	Other commercial products
Yes	Yes	No	Yes	Yes
Qualified yes	Qualified yes	No	Yes	Yes
No	Qualified yes	No	Yes	Qualified yes
Qualified yes	Qualified yes	No	No	Yes
Qualified yes	Qualified yes	No	No	Yes
No	Qualified yes	No	No	Qualified yes
Qualified yes	Qualified yes	No	No	Yes
Qualified yes	Qualified yes	No	No	Yes
No	Qualified yes	No	No	Qualified yes
Qualified yes	Qualified yes	Qualified no	Yes	Yes
Qualified yes	Qualified yes	Qualified no	No	Yes
Qualified yes	Qualified yes	Qualified no	No	Yes
Qualified yes	Qualified yes	Qualified no	Yes	Yes
Qualified yes	Qualified yes	Qualified no	No	Yes
Qualified yes	Qualified yes	Qualified no	No	Yes
No	No	Qualified no	Yes	Qualified yes
No	No	Qualified no	No	Qualified yes
No	No	Qualified no	No	Qualified yes
No	Qualified yes	Maybe	Yes	Yes
No	Qualified yes	Maybe	No	Yes
No	Qualified yes	Maybe	No	Yes
No	Qualified yes	Qualified yes	Yes	Yes
No	Qualified yes	Qualified yes	No	Yes
No	Qualified yes	Qualified yes	No	Yes
No	No	Yes	Yes	Qualified yes
No	No	Qualified yes	No	Qualified yes
No	No	Qualified yes	No	Qualified yes

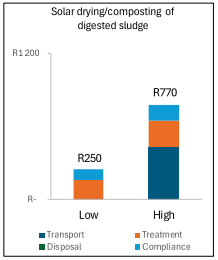
Figure 3: Example output from "WW Sludge Options" spreadsheet

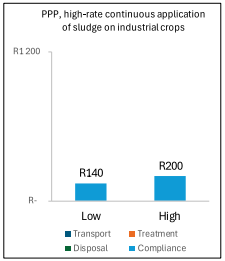
SUMMARY OF OPTIONS

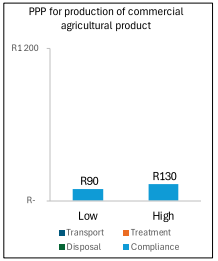
	Agricultural application of digested sludge	Solar Drying and Composting	High rate continuous application on industrial crops (PPP)	Production of commercial agriculture product (PPP)	Hazardous landfill disposal
Description	Application of dewatered sludge at agronomic rates, assuming distance of 50km or less	Treatment done by municipality to achieve an A1a product. Low-end assumes product collected by farmers. Does not consider a scenario where the product is sold, and does not include cost of classifying and registering product with Department of Agriculture.	Pumping digested sludge to field for application and production of industrial crops. Assumes costs are covered fully by fee/rental paid by private company to municipality. Only works with high MC sludge that can be pumped.	Complete outsourcing of commercial product production to a private company, who pays a small fee for receiving and beneficiating the dried/dewatered sludged from the municipality.	Transport and disposal of sludge in hazardous landfill, including treatment with lime to immobilise pollutants and trenching for disposal. Assume transport <50km.
Guidelines volume	2	5	4	5	3
Permitted /possible	Qualified yes	Yes	Qualified yes	Yes	Qualified yes
Sludge treatment (typ)	- Anaerobic digestion - Thickening - Dewatering / drying	- Anaerobic digestion - Thickening - Dewatering / drying	Anaerobic digestion (no dewatering)	- Anaerobic digestion - Thickening - Dewatering / drying	- Anaerobic digestion - Thickening - Dewatering / drying

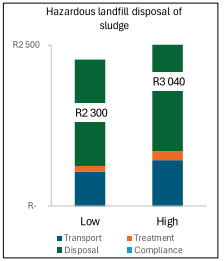
Estimated costs (R/ML WW treated) (range)												
Transport	R 540	R 720	R -	R 430	R -	R -	R -	R -	R -	R -	R 540	R 720
Treatment	R -	R -	R 160	R 220	R -	R -	R -	R -	R -	R -	R 90	R 130
Disposal	R 360	R 490	R -	R -	R -	R -	R -	R -	R -	R -	R 1 650	R 2 180
Compliance / Management	R 80	R 110	R 90	R 130	R 140	R 200	R 90	R 130	R -	R 10		
Total	**R 990**	**R 1 310**	**R 250**	**R 770**	**R 140**	**R 200**	**R 90**	**R 130**	**R 2 300**	**R 3 040**		











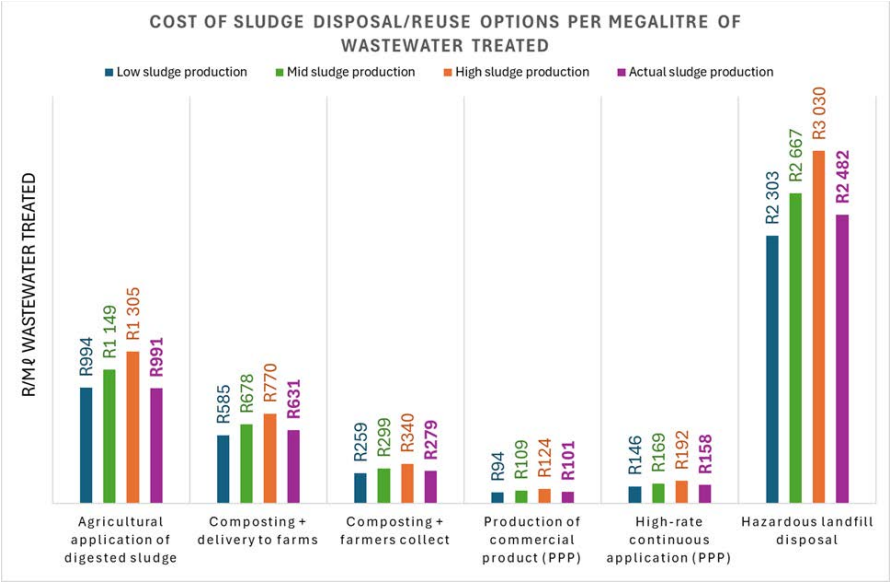


Figure 4: Estimated costs per megalitre WW treated for various options

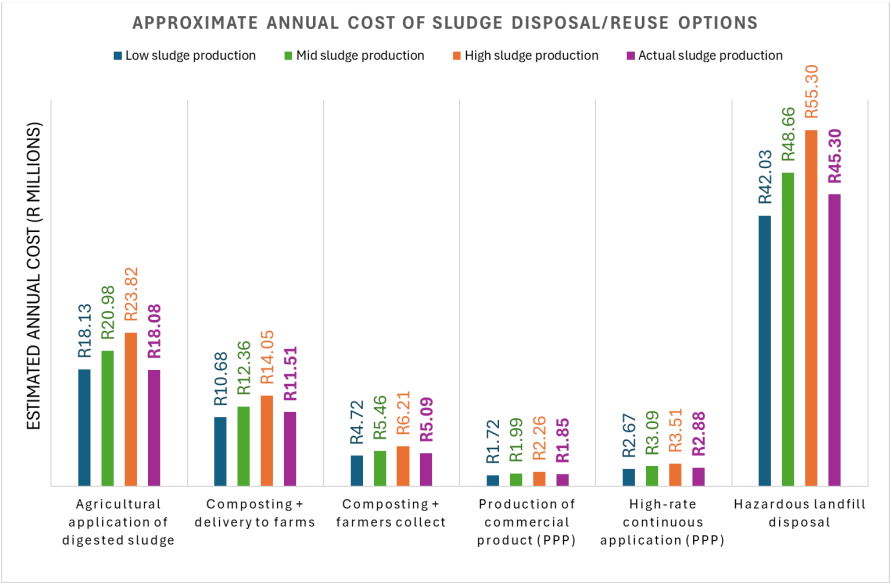


Figure 5: Approximate annual cost of different options (costs in 'R millions)


SLUDGE SUMP
CLARIFIER
NO.1

RESOURCES

- Guidelines for the utilisation and disposal of wastewater sludge Volume 1: Selection of management options, https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/TT%20261%20(vol%201)%20new.pdf

- Guidelines for the utilisation and disposal of wastewater sludge Volume 2: Requirements for the agricultural use of wastewater sludge, WRC report no. TT 262/06, https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/TT%20262-06.pdf

- Guidelines for the utilisation and disposal of wastewater sludge Volume 3: Requirements for the on-site and off-site disposal of sludge, WRC report no TT 349/09, https://www.wrc.org.za/wp-content/uploads/mdocs/TT%20349%20web.pdf

- Guidelines for the utilisation and disposal of wastewater sludge Volume 4: Requirements for the beneficial use of sludge at high loading rates, https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/TT-350-09.pdf

- Guidelines for the utilisation and disposal of wastewater sludge Volume 5: Requirements for thermal sludge management practices and for commercial products containing sludge, WRC report no. TT 351/09, https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/TT%20351%20web.pdf

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