SLUDGE MANAGEMENT

New strategy sets out sustainable path for sludge management in SA

As part of a broader project on sludge management, a research strategy has been developed to guide research in this field over the next decade. Article by Sue Matthews.

In the November/December 2024 issue of ***The Water Wheel***, Matthew Hattingh put an entertaining nautical spin on a topic many of us prefer to steer well clear of (See - https://bit.ly/3YxRwUW). Sludge – the word itself tends to conjure up an unappealing image and visceral response, and in this case referred to both sewage sludge from wastewater treatment works (WWTW) and faecal sludge from pit latrines and other forms of non-sewered sanitation (NSS). The article covered an online workshop titled "Sludge Management in South Africa: What's Possible, What's New and What's Next?", co-hosted in August by the Water Research Commission (WRC) and Isle Utilities, which was conducting a WRC-funded project aimed at analysing trends, innovations and advances in sludge management practices and technologies in low- and middle-income countries.

Although we might prefer to give sludge a wide berth – to continue the nautical metaphor – the topic is important in light of circular economy and decarbonisation agendas, policy shifts, and the environmental and public health risks of ineffective sludge management. The project team presented a thorough review of these issues in the research report (**WRC Report No. 3178/1/24**), which addressed the volume of sludge produced and how this can be reduced, the quality of sludge produced and how this can be improved for use or disposal, the management of faecal sludge in the context of South African sanitation, the beneficiation of sludge, and trends in innovation of both technologies and approaches to addressing sludge management.

Based on priority areas and challenges identified in that report, the project team also developed a high-level research strategy (**WRC Report No. TT 946/24**) to address key priority areas in the short, medium and long term over the next decade.

"The strategic priority areas were developed and aligned in a

nested structure, with shorter term priorities supporting the achievement of longer-term targets," they note. "For instance, the development of regulatory frameworks for emerging sludge management technologies will expand market opportunities and guide skills development programmes in the longer term, which in turn will support the continued development of sound governance practices within the industry and build resilience to adapt to the evolving needs of the sector in coming years."

Each priority area is presented as a challenge statement, after which a research design and methodology is proposed, and success criteria and outputs recommended. For the sake of brevity, the following summary merges these sections into a brief overview of each priority.

Short-term priorities (2025–2027)
The short-term priorities aim to tackle the most pressing research gaps that can be addressed rapidly.

- *Prioritising key sludge management challenges*

The top priority is to understand and reduce the volume of waste sludge, given that many WWTW are currently stockpiling sludge on site in response to national government's ban on the disposal of liquid waste to landfill. The ban, which came into effect in August 2019, applies to waste with a moisture content higher than 40% – and untreated sludge typically has a moisture content approximately double that. Stockpiling is clearly not a sustainable solution, so market-ready alternatives such as sludge volume reduction or beneficiation routes should be evaluated, considering their financial, technical, socio-economic, regulatory and environmental suitability. Current sludge production, stockpiles and space constraints at individual utilities and municipalities should also be surveyed to determine the greenhouse gas emission implications from sludge stockpiles, the volumes of sludge available for beneficiation, and the urgency of adopting alternative strategies.

One tool that could be useful in this regard is the Shit Flow Diagram (SFD), which helps understand how faecal waste moves through a municipal area, from containment at the point of origin to final disposal or reuse. To date only eight SFDs have been produced in South Africa, but the Sustainable Sanitation Alliance (SuSanA) has developed a digital SFD generation tool that produces the SFD graphic and accompanying report using data such as census results, Green Drop reports and surveys. The project team suggest that prioritising SFDs in the short term can support more informed decision making and planning for infrastructure development, deployment of novel solutions and capacity provision in wastewater treatment, as well as the development of emerging non-sewered sanitation technologies and value chains.

"The water sector is a notoriously slow adopter of innovation and highly resistant to the change brought about by innovation. Wastewater treatment operators are concerned with implementing untested and unfamiliar processes when existing systems are not functional," they note, pointing out that this resistance is a major barrier to the adoption – or even testing – of novel treatment technologies, and should be investigated further so that such concerns can be allayed.

- *Technology, innovation and markets*

Technology development and innovation are vital for finding new solutions and improving existing methodologies to address sludge management challenges. While much of the focus globally is on sludge beneficiation, the market for value-added products is still developing, and this is partly due to health and environmental safety concerns. Further research is needed to understand the willingness of markets to purchase sludge-derived products, particularly those making use of faecal sludge from NSS, which offers opportunities for local economic development and job creation. The project team suggest that business cases and financial models be developed for different sludge beneficiation and treatment technologies, as well as feasibility studies on both currently available NSS technologies and viable alternatives.

- *Regulatory framework*

South Africa's regulatory framework relating to sludge and its beneficiation is difficult for service providers and public sector entities to navigate, because individual pieces of legislation are not well aligned. The existing sludge management guidelines, published in five volumes between 2006 and 2009, are also incompatible with current legislation and circular economy principles, and do not cover NSS technologies. Regulations on novel solutions – anaerobic digestion sludge-to-energy schemes and Black Soldier Fly cultivation for protein and fertiliser production, for example – are lacking, which acts as a disincentive to the adoption of such innovations. New guidelines and regulations should therefore be developed through a consultative process, and research conducted to explore incentivisation and innovation adoption in sludge management.

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Medium term (2025–2029)
The medium-term priorities are aimed at tackling more systemic challenges that require longer timelines to address effectively.

- *Capacity building and training*

There is a dire shortage in South Africa of staff with sufficient competence to effectively operate anaerobic digestion systems and other novel approaches to sludge management, particularly those making use of digitisation and smart technologies. The

project team note that understanding the root causes of skills shortages, such as insufficient training opportunities or budgets, must be investigated. They recommend doing this through survey-based research and stakeholder interviews, with the findings documented in reports on the sector's capacity and capability shortages. Feasibility studies should be conducted on the implementation of mentorship programmes to transfer skills from senior operators to less-experienced staff. Developing new course materials and training programmes, or supporting existing training providers and SETAs, will also be crucial in building capacity and ensuring career progression.

- *Cross-sector approaches and integrated solutions*

While co-digestion and combined valorisation of sludge and solid organic wastes have been investigated from a technical perspective, the financial and economic implications as well as the supply-chain requirements to enable such integrated waste management systems need to be explored. Market readiness studies on products derived from these systems, such as fertiliser, also need to be conducted, because current technologies are not cost-competitive with chemical fertiliser production.

"In addition, public perception regarding sludge-derived products is poor, as an extension of poor confidence in public sector utilities to provide basic services such as water, sanitation and energy efficiently, let alone monitor and/or efficiently manufacture safe products using hazardous wastes as feedstock," note the project team.

- *Pilot scale to implementation*

Although anaerobic digestion potentially allows beneficial products, such as biogas and production feedstocks, to be produced from sludge, low bio-availability and biodegradability of sludge in South Africa creates challenges. Technologies to address this have yet to be tested in large-scale settings, highlighting the need for feasibility assessments that consider both the financial implications and energy demands of full-scale operation. Similar studies are needed to identify better and cheaper sludge drying and dewatering technologies, which are used to reduce sludge volumes and improve sludge quality for beneficial use.

Furthermore, the National Faecal Sludge Management (FSM) Strategy – finalised in April 2023 – prioritises the rapid deployment of NSS solutions to peri-urban and rural communities, but research on the barriers to adoption is essential. So too is the development of viable business and operational models that support adoption by providing low-skilled employment opportunities within the communities. The project team therefore suggest that community-based research and citizen-science approaches to the deployment and sustainable management of NSS technologies are tested and implemented.

"Inclusive and collaborative development, testing and deployment of sanitation solutions – where the communities benefiting from the solution are heard and their needs considered – will support sustainable and impactful implementation of NSS solutions," they note.

Long term (2025–2035)

The long-term priorities are aimed at building resilience in the research and innovation pipeline.

- *Advanced treatment and resource recovery*

The health concerns about contaminants of emerging concern (CECs) in wastewater, such as plastic particles, pharmaceuticals and personal care products, also apply to beneficiation of sludge. In the case of sludge-to-energy, air pollution and climate change impacts are additional concerns, given that existing WWTW have high carbon footprints. Further research is needed to build knowledge on the toxicological activity of various CECs present in sludge-derived products, including briquettes, construction materials, soil enhancers and fertilisers, and to develop technologies to remove or mitigate any negative effects. Climate-conscious solutions must also be identified and trialled to support the sector's contributions to emissions reduction targets and the Just Energy Transition.

Digital automation and smart technologies offer opportunities to reduce costs, improve efficiencies and support infrastructure and process management. Research and development of technologies such as AI and artificial neural network integrations in wastewater treatment and sludge valorisation systems will also open new opportunities for economic growth and employment in wastewater-related treatment systems. The project team suggest that digitisation strategies be developed for common technologies in sludge management – for example, anaerobic digestion and sludge minimisation approaches – and recommend that smart metering technologies be considered for sludge quantity estimation systems.

- *Governance*

"Overlapping authority on water treatment, pollution, waste management and resource recovery complicates the adoption of technologies, since multiple government departments and entities must designate resource recovery and sludge-based technologies, parts and components manufacturing. The overlap in authority also delays adoption due to bureaucratic barriers," note the project team, adding that the effort required to navigate procurement processes acts as a major barrier to innovation uptake. They recommend that policy-impacting research is undertaken on governance structures, and a greater understanding developed of the challenges and opportunities for procurement and beneficiation within the current regulatory framework. Adapted or novel contracting models for procurement that support rapid adoption and deployment of sludge management technologies should also be explored.

In addition, although regulations and policies are a critical element of South Africa's public services infrastructure, they become outdated if not reviewed and evaluated against modern research findings and international best practices. The project team therefore suggest that policy recommendations and updated regulations are produced on a continuous basis to ensure good governance.

- *Adaptation to evolving needs and challenges*

Currently, very few smart and digital technologies are available for sludge handling and disposal systems. Research and development of such technologies for monitoring and

digitisation of these systems will improve cost-efficiency and performance, while allowing operators finer control. Implementation strategies and regulatory support for their deployment will also be needed in the long term.

Further development of climate-smart technologies is recommended to address the current carbon emissions and high energy use involved in sludge management systems. Deployment of solutions should keep pace with climate research, and ensure that sludge can be handled, monitored and treated in more environmentally sustainable ways.

Take-home message

The project team emphasise that research and innovation in sludge management approaches and technologies is an active field of development, and there are already solutions available for many of the challenges faced. It is largely institutional and regulatory barriers that are inhibiting their adoption, so while the strategy lays out a roadmap for future research in the field of sludge management, the project as a whole has revealed a stark reality.

"More research will not move the needle substantially if technical solutions are not supported by application and scaling on the ground. An enabling regulatory and procurement environment is needed, and development of business models essential to ensure that the deployment deficit is addressed," they conclude. "This is important for further investment into the future of the water and wastewater sectors."

To view the original report, ***Sludge Management: A research strategy towards innovative and sustainable practices and technologies*** (**WRC Report No. TT 946/24**) by F Gouws, JE Burgess, C Ramcharan-Kotze and S Woolley, visit: https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/TT%20946%20final%20web.pdf