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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Sanitation

Investigating deep row entrenchment methods to rehabilitate sewage sludge

A WRC-funded study investigated the application of deep row entrenchment as a safe disposal method of pit latrine sludge.

The challenge of sustainable sanitation

While South Africa struggles to meet its sanitation backlogs, a substantial amount of existing basic sanitation infrastructure, which includes both conventional pit latrines and ventilated improved pit latrines (VIPs), has reached or is reaching the end of its design life. Urgent interventions are required to deal with the escalating accumulation of sludge in these basic units.

The options for safe disposal of this sludge are few. Because of the concentrated nature of pit sludge, only a limited quantity can be processed at a wastewater treatment works before chemical oxygen demand (COD) and solids overload of the system cause process failure. The 1,5 m^3 of sludge removed from a typical pit is the equivalent of 560 kℓ of typical sludge in terms of nitrogen (measured as TKN) and 1 064 kℓ of sewage wastewater in terms of total suspended solids.

Beneficial use of VIP sludge

South Africa's ***Guidelines for the Utilisation and Disposal of Wastewater Sludge*** encourage management options that include recovering energy, recycling the nutrients or synthesising commercial products from the sludge. Disposal without beneficiation is to be considered the last resort: when the sludge quality is of a high enough standard to be used beneficially, the sludge producer must prove to the authorities which beneficial use options were investigated and why they were not feasible, before disposal will be allowed.

The potential benefits of the nutrients (nitrogen, phosphorus and potassium as well as micro nutrients) and the high organic carbon content of sludge have been well demonstrated. Sludge is utilised for agricultural practices in many countries, and the burial of faeces and other household waste as a soil management system appears to have been used as early as the period 5000 BC by inhabitants of the Amazon Basin, where the technique produced a deep nutrient and organism rich soil which continues to have the capacity to support intensive agriculture and a high population density.

This is in contrast to the poor, leached soils adjacent to the area, which are typical of the equatorial regions of the world. The South African climate causes rapid decomposition of organic matter, which has contributed to the deterioration of the physical properties of cultivated soil. Improving these properties through the introduction of organic carbon present in sludge would yield a number of benefits in the South African context, including reducing reliance on expensive fertilisers derived from scarce phosphorus reserves and increasing food security where applied at the subsistence level.

Careful management

The utilisation of sludge must, however, be managed using stringent safety measures in order to prevent the uptake of harmful chemicals by humans or animals, contamination of the environment or the potential of exposure of humans to the pathogens found in the sludge. Surface application of sludge on land for agriculture therefore requires that the sludge is first treated to destroy pathogens and achieve stability. Other options currently in use are composting the sludge with other organic material or mixing or covering the sludge with soil in natural veld or tree plantations.

As a result, the WRC funded a study into the application of deep row entrenchment under South African conditions

Eucalyptus trees at planting in February, 2009 (top) and in January, 2012 (bottom).

with the aim of establishing whether the use of pit latrine and wastewater sludges as a fertiliser substitute for the agro-forestry sector can be recommended.

The development of the deep row entrenchment method in the 1970s and subsequent studies were reviewed as were the South African guidelines for the utilisation of wastewater sludge. No guidelines currently exist for the classification or utilisation of pit latrine sludge.

Pit latrine sludge was buried at different loading rates on a sandy site at a disused oxidation pond in Umlazi, south of Durban, and wastewater sludge from the Howick Wastewater Treatment Works was entrenched at a Sappi research site near Howick.

The sites were characterised and monitored over time in order to document the movement of nutrients out of the trenches and changes in groundwater over time.

The HYDRUS-2D program was used to model the movement of soil-water, phosphorus and nitrate. The fate of pathogens over time was also investigated. Tree growth was monitored in order to document differences in growth rates between trees provided with different loading rates of sludge and control groups. Two smaller studies were also conducted to investigate the impact of sludge on tree growth under controlled conditions, and the applications of deep row entrenchment for on-site sludge disposal.

Key findings

In all trials undertaken in this study, trees grown on sludge showed significantly greater growth than trees grown on native soil, with the exception of wattle trees in one study (where the difference was not significant), which may be attributable to the ability of wattle on poor soil to fix nitrogen from the atmosphere.

Eucalyptus grown on pit latrine sludge and wastewater treatment sludge showed similar benefit over control trees early in the study; however, by the end of the study the margins had decreased significantly. In addition, while trees planted on trenches containing more wastewater treatment sludge initially showed faster growth than trees grown on trenches containing less sludge this distinction later disappeared. It is unknown whether both of these trends would continue through the remainder of the growth cycle of the trees or whether further changes in the entrenched sludge would alter these trends. However, total biomass is proportional to the cube of diameter, and after 25 months of growth the trees grown over the sludge were still more than 60% larger than the control trees.

In a controlled 26-week study using constructed tree towers, eucalyptus trees grown over a core of pit latrine sludge showed nearly four times greater above ground biomass than the control group (which were given regular doses of liquid fertiliser), with mean leaf area 6,5 times greater, foliar nitrogen concentrations nearly three times greater and foliar phosphorus double that of the control group. In the large-scale trials nutrient concentrations in leaves and wood were not significantly enhanced in trees grown on wastewater sludge at approximately two years, however.

Nitrate, phosphorus and pH fluctuations in the downstream monitoring boreholes remained within acceptable ranges throughout the study, despite the volumes of sludge buried being significantly in excess of agronomic rates. The HYDRUS-2D model was found to provide meaningful predictions of soil-water, phosphorus and nitrate movement at the study sites.

Values for volatile solids, COD and moisture decreased rapidly during the first year of entrenchment for pit sludge, with slower degradation indicated thereafter. While a significant number of helminth ova were found in freshly exhumed pit latrine sludge, after 2,8 years of entrenchment less than 0,1% were found to be potentially infective and none of the eggs contained motile larvae. **If sludge is entrenched without contamination of the surface soil occurring, it provides a safe means to contain pathogens and thus represents a utilisation option that is appropriate even for untreated sludges or VIP sludge.**

Recommendations

For municipalities in South Africa, the deep row entrenchment method opens up a range of possibilities for the disposal of both wastewater and pit latrine sludge, overcoming the problems associated with the stabilisation of sludges, while providing benefits to non-edible crops and to soil. Potential risks to the environment or public health can be managed effectively with periodic monitoring of groundwater and soil.

Partnerships between municipalities and forestry could provide mutual benefit to both, with sludge handled, applied and monitored by forestry companies on their own land or with sludge entrenched and monitored by municipalities on municipal land with a forestry company contracted to manage a timber crop on the entrenchment site. On-site entrenchment of pit latrine sludge at the household level accompanied by planting of trees where space is available overcomes the difficulties and costs associated with the transport, treatment and disposal of sludge.

Entrenchment on small decentralised plots is another option which may prove useful to municipalities. A guideline compared in consultation with local experts is provided in the final report of the WRC study to facilitate implementation of the deep row method. This is based on South African legislation and regulations, the recommendations of studies conducted in the US over the past 40 years, and the knowledge gained from this research.

Further study of the impact of deep row entrenchment of sludge would allow the technique to be optimised in terms of benefits to a fruit or timber crop grown on the sludge and improving the cost-effectiveness of entrenchment techniques. In addition, a better understanding of the changes in and movement of sludge would enable minimum criteria for monitoring to be developed to ensure that risks are properly managed without incurring undue costs.

The guidelines provided in this document can be developed into an authoritative regulation adopted at the national level to facilitate broader application of this technique.

Further reading:
To order the report, ***Investigating the potential of deep row entrenchment of pit latrine and wastewater sludges for forestry and land rehabilitation purposes*** (**Report No. 1829/1/11**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za, or Visit: www.wrc.org.za to download a free copy.