by Filipe Figueira

MicroSludge wins over the skeptics

An independent review of the full-scale 2004 demonstration of a sludge treatment process confirms that after MicroSludge pretreatment, volatile solids reductions in excess of 90% were achieved in waste-activated sludge after 13 days. Without pretreatment, reductions of 20% are typically expected under similar conditions.

"When you tell people that your technology enables anaerobic digesters to achieve 95% volatile solids reduction (VSr) of waste activated sludge (WAS) in approximately 13 days, compared to 15 to 20% (Water Environment Federation Manual of Practice, 1998), they are inevitably going to be a little skeptical," said Dr. Rob Stephenson of Paradigm Environmental Technologies and inventor of the MicroSludge process. "But since a third-party report by CH2M Hill confirmed our results, people are taking our technology much more seriously."

The engineering firm CH2M Hill released the report on 9 March 2005. The report reviewed the full-scale demonstration of MicroSludge at the Chilliwack wastewater treatment plant in Vancouver, British Columbia, Canada, and confirmed Paradigm's earlier claims.

The Canadian Manufacturers & Exporters and National Research Council of Canada also awarded the 2004 Canadian Innovation Award for Environmental Technology (BC/Yukon) to Paradigm, based in Vancouver, British Columbia, for its MicroSludge technology.

The MicroSludge technology is a simple, modular system that uses caustic and high-pressure homogenisation to liquefy microbial cells in WAS prior to anaerobic digestion. The pressures used are so intense that microbial cells walls are liquefied and destroyed. Scanning electron microscope images of the WAS before and after MicroSludge graphically illustrate the effect of the process; however the real impact of the process comes in the performance of the anaerobic digester.

The 2004 Chilliwack trial of MicroSludge provided impressive results. The Chilliwack Wastewater Treatment Plant is located just outside Vancouver and serves a population of 70,000. The trial compared the performance of the plant's mesophilic anaerobic digesters, treating a combined 65% primary and 35% WAS feed, both with and without MicroSludge.

The CH2M Hill report concluded that MicroSludge greatly increased the rate and extent that WAS is degraded. On average, the process achieved volatile solids reductions of 78% in the primary/WAS sludge mix. The VSr of WAS alone was approximately 95%. These results indicate that MicroSludge can considerably reduce a plant's residuals disposal costs.

For example, at a typical wastewater treatment plant in North America serving about one million people generating a 50:50 mix of WAS and primary sludge, the total biosolids requiring anaerobic digestion would total approximately 40,000 dry tonnes per annum. A conventional mesophilic anaerobic digester being fed 50% primary sludge and 50% WAS would normally achieve VSr of 60% in primary sludge and VSr of as high as 30% in WAS after 15 days digestion. This would result in an overall VSr of 45%. For 40,000 dry tonnes of biosolids that are 80% volatile, 15,000 dry tonnes of volatile solids would be digested and approximately 25,000 dry tonnes of total solids would remain as residuals for disposal. This represents 37% overall reduction in total solids by anaerobic digestion.

> Rob Stephenson, Paradigm Environmental Technologies
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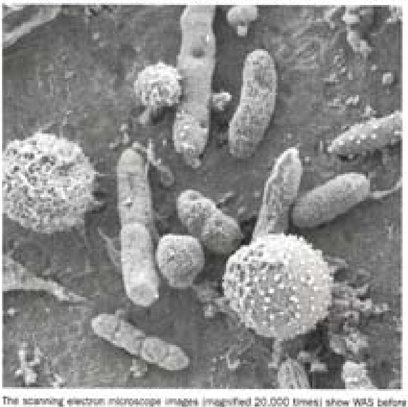
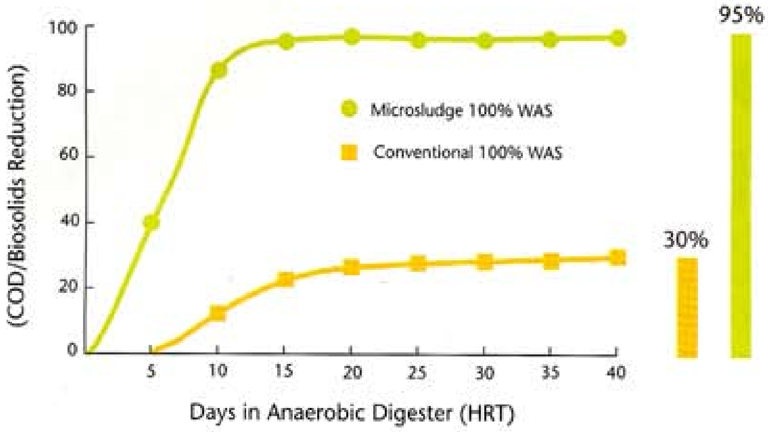
> **Wastewater operators are attracted by the potential for huge reduction in residual biosolids and a corresponding significant increase in biogas production. It makes good economic sense for most plants to adopt the system.**

Under the same feed conditions but with MicroSludge processing of WAS, a VSr of 95% in WAS can be expected after 15 days HRT. With no additional effect on the primary sludge, the overall VSr would therefore be 78% with MicroSludge. Starting with 40,000 dry tonnes of biosolids, 25,000 dry tonnes of volatile solids would be digested, leaving approxi-



The scanning electron microscope images (magnified 20,000 times) show WAS before (left) and after (right) the MicroSludge process. Homogenisation destroys microbial cells. The resulting liquefied sludge is then fed into a conventional mesophilic (37°C) anaerobic digester (CMAD) where the sludge is rapidly converted to methane and carbon dioxide gas. Digestion becomes highly accelerated because the microbial cell membranes are now destroyed. Conventionally, only 30% of the WAS is converted to biogas, but with MicroSludge, approximately 95% is converted.



Improved digester performance

mately 10,000 dry tonnes of total solids as residuals for disposal. This is a 74% overall reduction in total solids by anaerobic digestion with MicroSludge.

These performance improvements bring a number of economic benefits to wastewater treatment plants. The lower quantity of residuals reduces costs for dewatering, drying and trucking. In addition, for capacity-constrained wastewater treatment plants, lower HRTs mean that throughput is increased and capital costs for additional digester capacity can be avoided.

Harnessing energy in biosolids

Waste activated sludge represents an exceptionally rich and renewable energy source. Until now, anaerobic digesters have been ineffective at digesting WAS. This poor biogas production has resulted in just a marginal economic viability of operating microturbines and CHP at some wastewater facilities. However, using MicroSludge, one tonne of WAS can generate 500 m^3 of methane – an approximately 300% increase over conventional digestion of WAS. Harnessing the methane to generate electricity and heat can significantly offset a wastewater treatment plant's energy needs for on-going operations. In some instances it could make a facility a net-energy generator.

MicroSludge does use considerable energy to liquefy the bacterial cells of WAS, but four times more energy can potentially be recovered from WAS as electricity and waste heat from biogas, as compared to the electrical requirements of MicroSludge. On economic terms, the total operating cost of MicroSludge processing, including electricity, caustic and maintenance is approximately US$50/dry tonne TWAS (assuming a unit power cost of US$0.05/kWh). However, the incremental value of additional biogas and heat generated as a result of enhanced VSr by MicroSludge over conventional digestion is approximately US$90/tonne, making the process highly economic on the basis of lifecycle costs. This increased on-site energy generation reduces the risk of critical operation disruption in the event of power grid failures.

The MicroSludge process therefore allows wastewater treatment plants to extract the maximum economic value from biosolids. Currently, the estimated value for stabilised biosolids used as fertiliser is approximately US$10/dry tonne, not allowing for trucking costs. But wastewater treatment plants often supply biosolids to farmers for free and are generally charged tipping fees at landfills. By converting biosolids to biogas, their value increases to over US$115/dry tonne, depending on local electricity costs.

The two direct benefits of MicroSludge are a significant reduction in residual disposal costs and energy costs. The total net operational benefits of these savings over a one-year period would total almost four million dollars, depending on electricity costs and biosolids disposal costs. But there are also a number of other indirect economic benefits, including lower viscosity of TWAS for easier pumping and digester mixing.

Because odour from residual biosolids is generally due to readily degradable volatile solids, volatile fatty acids, total reduced sulphur, and nitrogenous compounds, MicroSludge's high VSr of WAS improves the odour characteristics of residuals. A Water Environment Research Foundation (WERF) study (2005) measured the odour of MicroSludge-processed TWAS from the Chilliwack plant and compared it with the odour of untreated TWAS from the same plant. The WERF study confirmed that the odour of the digested MicroSludge TWAS residual biosolids was significantly lower than for untreated activated sludge.

The CH2M Hill report also looked at the dewatered sludge cake and sludge dewatering filtrate characteristics at the Chilliwack trial. It found that aside from a reduction in the total mass of digested sludge to be dewatered, the MicroSludge process did not significantly alter the operation or the performance of the downstream sludge dewatering units. With MicroSludge processing, the filtrate BOD and COD concentrations were typically less than 100 mg/L and 400 mg/L, respectively. These values are approximately the same or less than that of typical raw domestic wastewater. The filtrate TKN and ammonia-nitrogen concentration were typically around 800 mg/L and 450 mg/L, respectively. These values are as expected in the return stream in a plant having anaerobic digesters.

The MicroSludge performance challenges the conventional expectations of what is possible at a traditional wastewater facility, and it provides a field-proven technical solution for dealing with residual biosolids, rising operating costs, and the need to improve public perception of plant operations.

Author's Note

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• Enquiry No.73 •

CH2M Hill report verifies 90% volatile solids reductions

The CH2M Hill report evaluated the results of the full scale 2004 demonstration of the prototype MicroSludge plant at the Chilliwack wastewater treatment plant. The report was authored by Barry Rabinowitz, Ph.D., P.Eng. and reviewed by Dr. Glen Daigger, CH2M Hill's chief technology officer and technical director for the its water business group, and by Peter Burrowes, P.Eng., CH2M Hill's global technology leader for residuals management. The report concluded:

• MicroSludge greatly increases the rate and the extent that waste activated sludge is degraded in a conventional mesophilic anaerobic digester.

• Increased volatile solids reductions in the digester should significantly reduce the quantity of residual biosolids to be disposed, and result in higher production of biogas.

• Largest operating cost is for electrical power, which is estimated to be approximately US$ 38 per dry tonne of TWAS processed at a WAS concentration of 4% TS, assuming a unit power cost of US$ 0.05/kWh.

• Energy benefits can be realised in three ways:

i. Electrical energy from biogas conversion of approximately 970 kWh per dry tonne of WAS processed, or net additional 210 kWh per dry tonne of WAS processed;

ii. Heat energy from biogas conversion of approximately 1,140 kWh per dry tonne of WAS processed; and

iii. Heat resulting from high-pressure homogenisation of approximately 580 kWh per dry tonne WAS processed at a WAS concentration of 4% TS or approximately 385 kWh per dry tonne WAS processed at a WAS concentration of 6% TS.

Assuming unit electrical and heat energy costs of US $0.05/kWh and US$ 0.025/kWh, respectively, the total value of the additional net recoverable energy resulting from MicroSludge pretreatment is projected to be in the order of $91 per dry tonne of WAS processed at a 4% solids concentration or approximately 150% of the total O&M cost of processing. For 6% TWAS, the value of the net recoverable energy is projected to rise to approximately 200% of the total O&M costs of MicroSludge pre-treatment.