

Frequently Asked Questions about *MicroSludge*[®]

GENERAL

Q. Is MicroSludge a proven technology?

A. Yes. The core technology used in MicroSludge, namely the Cell Disrupter, has been used for decades in a number of industrial, food processing and pharmaceutical applications. Thousands of these machines (high pressure homogenizers) are in operation worldwide. MicroSludge is simply a new application of a very well established technology.

Q. I've heard similar claims of high VSr from other technologies, what's different about MicroSludge, and why should I believe your claims?

A. MicroSludge's performance claims are based on sound science and verifiable performance data. Reports have been written by engineering consultants and scientists, and a number of papers about MicroSludge have been presented by these consultants and scientists at technical conferences. Paradigm is careful about not making performance claims that haven't been verified by qualified third parties or industry experts. MicroSludge's technical performance, such as its ability to achieve very high levels of WAS solubilization, is unmatched by any other sludge pre-treatment technology. This technical performance has been proven over the eight years that MicroSludge has been in development, and during commercial scale installations.

Q. How many MicroSludge systems have been installed?

A. Our first commercial scale demonstration in 2004 was near Vancouver, BC. Our second commercial scale demonstration in 2005 and 2006 was in Los Angeles County at the Joint Water Pollution Control Plant. Our third commercial scale MicroSludge unit will be completed in Des Moines, Iowa and will be operational in June 2007.

Q. Why does Paradigm insist on conducting microbial activity tests?

A. We've developed a simple testing program that quickly determines if MicroSludge can improve anaerobic digestion and biogas production at a particular wastewater treatment facility. Anaerobic digesters can only benefit from MicroSludge if they have viable population of microbes present that are able to convert the solubilized WAS into compounds that in turn are converted into biogas. The vast majority of digesters tested by Paradigm have exhibited ideal conditions for realizing the performance improvements of MicroSludge. However, in some instances there may be factors present that inhibit the ability of microbes to degrade sludge and generate biogas. Successful completion of the testing program allows facilities to be confident that MicroSludge can deliver the expected performance improvements and economic benefits.

Q. What level of pathogen destruction is achieved by MicroSludge?

A. MicroSludge achieves very high levels of pathogen destruction. However, MicroSludge only processes waste activated sludge. Therefore, in plants that co-digest MicroSludge processed WAS and with primary sludge that contains high levels of pathogens, the pathogen level in the digester feed will remain high.

In facilities where WAS-only digestion is possible, MicroSludge achieves a high level of solubilization of WAS. Therefore, following anaerobic digestion of MicroSludge processed WAS, the particulate solids concentration may be small enough to forgo dewatering altogether. Instead, MicroSludge processed WAS only digester effluent would likely by-pass dewatering and be returned to the plants head works where pathogen level is not important.

Q. How can you claim to reduce fixed solids in the WAS?

A. MicroSludge solubilizes both volatile and fixed solids of WAS. The fixed solids remain in solution during anaerobic digestion and do not report to the cake. The dewatering liquid that is returned back to the plant head works will contain significantly higher levels of dissolved fixed solids than would be the case without MicroSludge. However, the major constituents of the fixed solids in the dewatering liquid are not heavy metals, phosphorous, or BOD, and therefore pose no additional load to the WWTP or risk to the environment or risk of exceeding regulatory permit levels.

Q. How does MicroSludge affect BNR (biological nutrient removal) sludge?

A. We expect that MicroSludge will lyse BNR sludge similarly to WAS except higher concentrations of soluble phosphorus prior to digestion will result.

Q. Can MicroSludge be used to improve aerobic digestion?

A. Yes. Solubilizing WAS is the rate limiting step for both anaerobic as well as aerobic digestion, so from this standpoint, MicroSludge can help. However, anaerobic systems typically have a cell yield of just 5%, whereas aerobic systems can be ten times this at 50% or higher cell yield. So in theory, for one dry tonne of WAS processed by MicroSludge, 500 kg of new WAS would be produced aerobically compared to 50 kg anaerobically. Additionally, no methane is generated by aerobic stabilization.

DIGESTER OPERATIONS**Q. Will the addition of sodium hydroxide change the pH in my digester?**

A. No. We have found an insignificant effect on digester pH at all of our trials and pilot studies. Immediately upon caustic addition, the pH of WAS typically increases by 1 or 2 pH units. Immediately upon cell disruption, the pH of the MicroSludge processed WAS typically drops by 1 pH unit. Anaerobic digesters continually generate carbon dioxide to quickly buffer any remaining sodium hydroxide to a neutral pH. The addition of caustic during MicroSludge processing increases the alkalinity in WAS and thereby helps to buffer rapid pH changes in the digester.

Q. Is there any risk of sodium toxicity to my digester?

A. No. Not enough sodium hydroxide is added to cause a problem to the digester microbes.

Q. Does MicroSludge cause elevated levels of ammonia to cause a problem in my digester?

A. No. The small increase in ammonia concentration (10 to 20% greater than for conventional anaerobic digestion) is not high enough to cause inhibition of anaerobic digesters at neutral pH.

Q. Does MicroSludge cause elevated levels of sulphide in the digester?

A. Yes. The total increase in sulphide that is generated will increase roughly in proportion to the increase in VSr. However, much of the increase in dissolved sulphide will be removed from the liquid phase because it readily precipitates with available metals.

Q. Does MicroSludge cause increased struvite in an anaerobic digester?

A. No. Struvite (magnesium ammonium phosphate) can be formed when soluble magnesium, soluble ammonia, and soluble phosphorus are each present under alkaline pH conditions, low levels of soluble solids, and low temperature.

MicroSludge processing of WAS releases phosphorus and ammonia into solution, but does not impact the concentration of magnesium, typically the limiting nutrient for struvite formation. Although caustic is added by MicroSludge, the continuous supply of CO₂ in biogas buffers the digester pH back down to neutral pH levels. Additionally, the 25 C° (45 F°) temperature increase and massive dispersion of solids of WAS into the liquid phase does not favour struvite formation.

Q. Does MicroSludge cause digester instability or sour the digester?

A. No. MicroSludge enables extraordinarily high concentrations of VFAs to be rapidly formed that are readily converted to biogas. In our experience, digesters remain very stable.

Q. Can MicroSludge enable greater digester throughput?

A. Yes. Without sludge pretreatment, WAS is the rate limiting step for anaerobic digestion of sludge. Typically, primary sludge degrades fairly readily and to a much larger extent than WAS. By liquefying the cells of WAS, MicroSludge addresses the rate limiting step of anaerobic digestion of WAS, speeding up sludge stabilization.

Just how far the HRT can be reduced in any particular digester may be site specific. For co-digestion with MicroSludge processed WAS, anaerobic digestion of primary sludge becomes the rate limiting step, and the extent of overall HRT reduction for stable digestion will depend on the rate of primary sludge digestion.

Using WAS processed by MicroSludge, we have operated conventional full-scale WAS-only anaerobic digesters at less than 9 days HRT and achieved stable performance.

Q. Does MicroSludge help to reduce digester foaming?

A. Yes. We asked Dr. David Jenkins (retired Berkeley professor and internationally recognized expert on filamentous microorganisms and foaming) to examine WAS before and after MicroSludge. Dr. Jenkins observed that MicroSludge appears to almost entirely destroy the filamentous microbes. This finding was repeated on WAS samples from other WWTPs. Dr. Jenkins will inspect sludge samples before and after MicroSludge processing (a small fee is involved).

DOWNSTREAM IMPACTS

Q. Does MicroSludge cause elevated levels of phosphorus in the digester effluent?

A. No. While MicroSludge solubilizes phosphorus in WAS, phosphorus doesn't stay in solution for long under normal anaerobic digester conditions. Phosphorus quickly re-precipitates into an insoluble form as precipitates of iron, calcium, aluminum and magnesium and is removed from the digester in the dewatered cake.

Q. Does MicroSludge cause problems with dewatering?

A. No. WAS is typically the main culprit behind poor dewatering performance of anaerobically co-digested primary sludge and WAS. MicroSludge liquefies WAS and enables it to be more effectively digested in anaerobic digesters. Therefore, the effluent from MicroSludge-fed digesters has very low levels of WAS and dewateres in a similar way to digested primary sludge. Based on our experience, MicroSludge does not decrease dewatering performance, either in terms of cake dryness, polymer requirements, or quality of the dewatering liquid.

Q. Does the BOD level of dewatering liquid become too high with MicroSludge?

A. No. There is no significant difference in BOD concentration compared to conventional digestion. MicroSludge greatly increases the bio availability of WAS, and the biodegradable portion (measured as the BOD) almost completely degrades in an anaerobic digester.

Q. Does MicroSludge elevate metals in the dewatering liquid?

A. No. By liquefying WAS, metals in WAS are released by MicroSludge into the liquid phase prior to anaerobic digestion. Hydrogen sulphide that is formed by anaerobic digestion precipitates almost all heavy metals back to their insoluble form. Consequently, the concentration of metals in the dewatering liquid is typically not affected by MicroSludge.

Q. Does MicroSludge elevate metals concentration in the digester cake?

A. Possibly, depending on metals concentration in incoming wastewater. Heavy metal concentrations are normally quite low in municipal WAS, but can be quite variable in primary sludge. MicroSludge liquefies WAS so that very little MicroSludge processed WAS actually becomes part of dewatered cake. This means that the portion of primary sludge making up the cake will increase, and therefore so will the heavy metals concentration. In most instances, metals concentrations will still be far below allowable limits.

Q. What effect does MicroSludge have on odors of the digested residuals?

A. According to WERF, approximately 90% of the odors of digested sludge residuals are due to volatile organic sulfur containing (VOSC) compounds. These VOSCs are both formed and degraded by methane producing bacteria in anaerobic digesters. The WERF odor study tested MicroSludge processed sludge at Los Angeles County and found an odor reduction of at least 50% for the co-digested 68% primary sludge and 32% WAS. For lab scale digestion of MicroSludge processed WAS - only digestion, the study authors reported complete removal of the VOSCs, eliminating the odor.

MAINTENANCE & OPERATIONS

Q. How much maintenance does MicroSludge require?

A. MicroSludge is automated and requires minimal user intervention. Maintenance and spare costs are estimated at approximately \$20 per dry tonne of sludge processed. There are three main wear parts that require routine maintenance. These are:

Item	Maintenance interval	Task duration
Cell Disrupter Valve	3 weeks	10 minutes
Check Valves	6 weeks	30 minutes
Cylinder packing	occasional	1 hour
Oil change, drive belts	3 to 6 months	1 hour

(* Based on 24/7 operations)

These tasks can be easily performed by plant staff, or by APV service personnel who are located in most large metropolitan centers.

Q. Can primary sludge be processed with MicroSludge?

A. No. MicroSludge lyses microbial cells in WAS. MicroSludge is focused on solubilizing WAS because this is the portion of sludge that degrades so poorly in anaerobic digesters. The benefits on anaerobic digestion of processing of primary sludge with MicroSludge - if at all possible - would be minor.

Q. Is thickening of WAS recommended for MicroSludge processing?

A. 5 to 8% TS in WAS is recommended prior to MicroSludge processing. WAS thickening reduces the operating cost per dry tonne of WAS processed directly in proportion to WAS thickness. Note that WAS needs to be thickened separately from primary sludge.

Q. How much reject material is screened from WAS prior to MicroSludge?

A. None. The rejected material is either sent to the digester or back to the head works, so no additional waste for handling or disposal is generated. Caustic addition to WAS, by greatly lowering the viscosity, enables finer screening (1 to 2 mm) of thickened WAS than would otherwise be feasible. Screening prevents plugging in the system by hair, bits of plastic, wood, snail shells, and insect wings, etc. In any event, these materials would not benefit from being passed through MicroSludge anyway. They by-pass MicroSludge and are either sent to drain where they will go back to the head works, or they can go directly to the anaerobic digester. Typically less than 1% of the total dry matter of WAS by-pass the cell disrupter.

Q. Can MicroSludge be operated in a batch mode?

A. MicroSludge is fully automated and designed to operate in continuous mode. However, the system is very flexible and can also be operated in a batch mode where suitable.

ENERGY GENERATION & USE

Q. MicroSludge uses a lot of electricity. How can it be a net energy producer?

A. MicroSludge does use a lot of electricity. This energy input is necessary to achieve high levels of WAS solubilization. However, the significant increase in VSr and resulting biogas production generally exceeds the energy used to run the system. Clearly, conversion of the biogas to electricity and/or heat is needed to be a net energy producer.

For each dry tonne of WAS at 80% VS content and 95% VSr, approximately 4,525 kWh of energy from biogas are potentially available (936 m³/dry tonne VSr, 64% CH₄, 9.94 kWh/ m³ CH₄). At 30% conversion of biogas to electricity, 1,358 kWh could potentially be produced for each dry tonne of WAS. MicroSludge therefore uses about 37% of the electrical energy that is available from the biogas electricity potential of WAS. The recoverable waste heat (40 to 50% of the energy value of biogas) plus the 25 C° (45 F°) temperature increase caused by MicroSludge processing are additional energy benefits of the process.

Q. How much electricity does MicroSludge use?

A. At 6% TS in WAS, MicroSludge uses approximately 496 kWh per dry tonne of WAS processed. Different TS concentrations in WAS result in proportionally more or less electrical consumption. Each Cell Disrupter is powered by a 150 horse power motor. The electrical draw at 460 VAC is as follows: 140 A per Cell Disrupter, and 30 A for the Central Processing Unit.