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Project: Process Evaluation of Solid Grease Removal using Micro-Solve in the City of Beaumont Wastewater Collection System

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Date: October 23, 2014

Re: Summary of Micro-Solve degreasing experiments

This report summarizes the findings of substrate characterizations and treatment experiments that evaluate the performance of Micro-Solve in removing solid grease accumulation in the sewer network of the City of Beaumont wastewater collection system. The objectives are to: (1) characterize the organic strength and nutrient contents of Micro-Solve as relevant to aerobic biological wastewater treatment, (2) determine the efficacy of Micro-Solve in removing/disintegrating hardened grease, and (3) assess the biodegradability of the treatment product after the degreasing action of Micro-Solve.

1. Characteristics of Micro-Solve and Hardened Grease Samples

Table 1 shows the physical and chemical characteristics of a Micro-Solve sample provided by Evergreen Southwest. The sample is a blue, low-viscosity liquid with a petroleum odor. The specific gravity is 0.81 (81 % of the weight of water at the same volume). The liquid is hardly soluble in water (clear phase separation after mixing with water), and forms an oily film on water surface when it is applied in small dosages (<1000 ppm). It contains a high level of COD (1.6 Kg/L) and a moderate level of nutrients (nitrogen and phosphorus). Based on the measured organic content, application of each gallon of Micro-Solve gives 13.3 lbs of COD loading to the Beaumont Wastewater Treatment plant that receives approximately 50,000 lbs of COD loading per day. Under normal application scenarios (detailed in Section #3), the risk of substantial increase of organic load to the treatment plant is low. It is recommended, however, that the application volume of Micro-Solve under extreme cases where a large quantity of Micro-Solve is applied within a short period of time be recorded to prevent pulse organic input. The nutrient levels are small compared to the typical loading to the plant and therefore not a concern. The measured physical characteristics are consistent with the product description reported in the technical documents of

Evergreen Southwest. The relatively low specific gravity of Micro-Solve (0.81) suggests that the liquid would float at top of wastewater under typical flow conditions in sewer lines (i.e., the flow is unlikely to mix a significant amount of Micro-Solve into water phase). It is therefore recommended that mixing of Micro-Solve with the wastewater be introduced during application.

Table 1: Characterization of Micro-Solve liquid

Characteristics of Micro-Solve	Value	Measurement Notes
COD (Kg/L)	1.6	Based on the volume of Micro-Solve
Total Nitrogen (mg/L)	530	Based on the volume of Micro-Solve
Total Phosphorous (mg/L)	1380	Based on the volume of Micro-Solve
Specific Gravity	0.81	Lower than the 0.91 noted in the MSDS
Solubility	N/A	Form thin oily film on water surface at <0.1 % dosage

2. Characteristics of Hardened Grease Samples

Table 2 shows the physical composition of the harden grease samples collected from the City of Beaumont wastewater collection system. The grease is a white, wet solid with a texture similar to that of solid wax. It has a light municipal wastewater odor, a high moisture content (62%), and a small fraction of inorganic solids (1%). The harden grease has a specific gravity ranging from 0.9 to 1.1 due to the various quantity of inorganic solids and air/gases trapped in the grease samples.

Table 2: Characterization of hardened grease collected from City of Beaumont sewers

Characteristics of Hardened Grease	Value	Measurement Notes
Moisture (wt %)	62	Weight loss after evaporation at 105 °C
Grease (wt %)	37	Weight loss at 550 °C in the presence of oxygen
Fixed Solids (wt %)	1	Remaining weight after heating in the presence of oxygen at 550 °C
Specific gravity	0.9-1.1	Variable due to different amount of inorganic solids and air/gas incorporated in the samples

3. Performance of Micro-Solve on the Micellar Solubilization of Hardened Grease

Figure 1 shows the physical appearance at different time points after dosing Micro-Solve into 500 ml of tap water containing 10 gram of solid grease. To simulate the anoxic condition typically of sewer lines, the batch reactors are sealed with alumina foils. The experiments are performed in an automated shaker with the temperature controlled at 25±0.1 °C. As shown in Figure 1, it is clear that even a small dose of Micro-Solve is capable of promoting micellar solubilization of the solid grease. The process is characterized as by a slow dissociation of the hardened grease, followed by micellar suspension of the grease in the aqueous phase. Significant solubilization is observed after 12 hours of application and the turbidity of the water gradually increases due to the increasing amount of grease suspension. Interestingly, a higher dosage does not result in a higher degree of solubilization. At dosages higher than 1000 ppm, a clear phase separation

between water and the applied Micro-Solve occurs. Under this circumstance, the Micro-Solve liquid tends to be attached to the surface of the grease without forming micellar suspension in the water phase, and the solid grease remains largely in the original form.

To quantify the amount of solid grease suspended in the aqueous phase due to the action of micellar solubilization of Micro-Solve, the total COD concentrations of the grease suspensions are measured. A higher COD concentration means that more solid grease is solubilized by Micro-Solve. The quantity of remaining solid grease that can be retained by a 1-mm screen (i.e., the grease particles that have a size greater than 1 mm) is also determined. These results are shown in Table 3. The data show that the COD concentrations increase with respect to the reaction time, and that higher COD levels are present in the aqueous phase at dosages of <500 ppm of Micro-Solve. At 1000 and 2000 ppm, the action of micellar solubilization seems to be limited. Two additional experiments are performed at very high dosages (20 ml Micro-Solve in 1 L of water and 40 ml of Micro-Solve in 1 L of water). It is found that the level of solubilization is also limited at these two high dosages. After the 72-hour treatment, more than 50% of the grease is dispersed into the aqueous phase at 50-ppm dosage (43% coarse grease remaining). Practically, the remaining grease, although has particle sizes > 1 mm, should also be removed from the clogged sewer lines under typical wastewater flow condition because of the breakup of the solid grease. The degreasing performance at dosage < 500 ppm is consistently better than the performance at dosage > 1000 ppm. The results are in agreement with the turbidity observations shown in Figure 1. Based on the finding, it is recommended that a long-term, low-dose application program be designed for the grease removal in field application.

4. Degradability & Potential Toxicity of the Grease Suspension after Micro-Solve Application

An experimental evaluation is performed to examine the biodegradability and potential toxicity of the grease suspension in the aqueous phase after the treatment using Micro-Solve. In the evaluation, we choose specific oxygen utilization rate (SOUR) as the metrics to indicate the acute toxicity and degradability of the grease suspensions under test. The activated sludge collected from the recycled sludge line at the City of Grove wastewater treatment plant is used as the seeding microorganisms for the SOUR measurement. A higher SOUR value suggests that the microorganisms can utilize or degrade the substrate under test, and therefore their respiration rate is higher compared to the rate when a suitable substrate is *not* present. For toxic substrates, the SOUR value is typically reduced significantly because of the adverse effect caused by the toxicity.

The measured SOUR values for the reference (i.e., zero dosage) and the grease suspensions after 72 hours of Micro-Solve treatment are shown in Table 3. For those samples with significant grease solubilization (25-500 ppm dosage), the SOUR values are significantly higher than the reference value. The measured SOUR values [20-30 mg/(hr-gMLVSS)] are similar to the values typically observed in the aeration basin of a conventional activated sludge system. At higher application dosages (> 1000ppm), the SOUR values are not different from the reference SOUR value, likely due to the low degree of grease solubilization at these dosages. The finding suggests that the treatment product of Micro-Solve is a benign substrate source and therefore readily biodegradable in an aerobic biological treatment system.

	25 ppm	50 ppm	250 ppm	500 ppm	1000 ppm	2000 ppm
Start						
After 1 day						
After 2 days						
After 3 days						

Figure 1: The level of micellar solubilization after application of Micro-Solve. All experiments were performed using 10 gram of hardened grease in 0.5-L tap water with continuous stirring at ~50 rpm.

Table 3: Levels of COD (mg/L) in the aqueous phase after applying Micro-Solve[1] Dosage[2]

Time (hrs)	0	0.025 ml in 1 L (25ppm)	0.05 ml in 1 L (50 ppm)	0.25 ml in 1 L (250 ppm)	0.5 ml in 1 L (500 ppm)	1.0 ml in 1 L (1,000 ppm)	2.0 ml in 1 L (2,000 ppm)	20 ml in 1 L[3] (20,000 ppm)	40 ml in 1 L[3] (40,000 ppm)
12	116		950	1100	466	209	225	1670	3170
24	68	1130	990	174	349	308	307	1490	2880
36	90		1107	1840	224	285	309		
48	91	2050	2312	2670	223	293	299	1700	3260
60	110		7740	3040	219	275	325		
72	122	2940	8770	4680	240	318	298	1700	3410
wt% grease remaining[4]	98%	65%	43%	63%	74%	82%	82%	90%	87%

1. Experiments were performed using 10 gram of hardened grease in 0.5-L tap water with continuous stirring at ~50 rpm.
2. Micro-Solve does not dissolve in water and therefore the dosage is presented as ml of Micro-Solve in 1 L of water. The parenthesis below indicates the concentration by volume if Micro-Solve is completely dissolved in water.
3. Phase separation observed (Micro-Solve floating on top of water layer)
4. The grease particles that have a size greater than 1 mm.

Table 4: Specific oxygen uptake rate (SOUR, mg/(hr-gMLVSS)) of the treated grease after Micro-Solve application

Dosage

Time (hrs)	0	0.025 ml in 1 L (25ppm)	0.05 ml in 1 L (50 ppm)	0.25 ml in 1 L (250 ppm)	0.5 ml in 1 L (500 ppm)	1.0 ml in 1 L (1,000 ppm)	2.0 ml in 1 L (2,000 ppm)	20 ml in 1 L (20,000 ppm)	40 ml in 1 L (40,000 ppm)
	11	24	29	25	20	12	10	11	10

*: using the aqueous solution after treatment without including the undissolved Micro-Solve liquid at top