HIGH STRENGTH WASTEWATER LITERATURE REVIEW

Sara F. Heger

Abstract

Most state's regulations do not have separate requirements for the design of onsite wastewater treatment systems (OWTS) for facilities with the potential for higher strength wastewater (HSW) characteristics such as from food service establishments and RV parks. HSW is defined by elevated levels of organics measured in biological oxygen demand (BOD_5), total suspended solids (TSS), and/or oils and grease (O&G). There is a growing understanding that all OWTS design must consider both hydraulic and organic loading. Pretreatment possibilities exist beyond simple primary treatment in a septic tank, but none have yet to be independently tested to a standard. There have been discussions and requests for development of a HSW standard for these pretreatment systems.

The literature available on the topic of HSW characteristics is rather limited and has a wide range of values. HSW organic values for BOD_5, TSS, and O&G vary greatly in the published data. BOD_5 was found to range from 100 – 3,685 mg/L, TSS from 142 – 4,375 mg/L, and O &G from 50 – 14,958 mg/L.

The first step in establishing a Standard-HSW is setting the key organic characteristics. The following raw wastewater values are recommended which are in the middle to high range of median levels in the published literature. These values represent the wastewater which be enter the first component in the treatment train which may be grease trap or septic tank.

- BOD_5 = 2,500 mg/l
- TSS = 1,200 mg/l
- O&G = 300 mg/l

In addition pH, temperature, alkalinity, surfactants, total nitrogen and phosphorus will be determined.

The second step in implementing a Standard-HSW is to set the hydraulic loading. Due to the large amount of fluctuation in loading at most facilities producing HSW it is recommended to follow a similar hydraulic loading and schedules as Standard 40 although this may not be a relevant issue as many of the systems will utilize flow equalization as part of their treatment system. On non-flow equalized systems, it is suggested to adjust the design loading to only have 20% of the flow from 6:00 AM to 9:00 AM and add this flow to the 11:00 AM – 2:00 PM time frame to reflect a larger usage over the lunch hour.

University of Minnesota, Water Resource Center, Onsite Sewage Treatment Program, 1985 Buford Ave, 173 McNeal Hall, St. Paul, MN 55108. sheger@umn.edu

Therefore the recommended design loading is:

- 6:00 AM – 9:00 AM 10%
- 11:00 AM – 2:00 PM 40%
- 5:00 PM – 8:00 PM 50%

The third implementation step is the laboratory development of a HSW "soup". The procedures developed to date to develop HSW are limited in their breadth and applicability. To closely mimic actual HSW, it is recommended to start with raw residential wastewater and supplement with complex and simple proteins, sugars and O&G to achieve the suggested key characteristics. Due to the challenges of creating the supplemented HSW a 30% tolerance plus or minus from the BOD_5, TSS and O&G levels set in the Standard-HSW should be allowed. The total nitrogen in this wastewater will replicate typical wastewater with values in the range of 60-80 mg/L.

Introduction

Several states including Minnesota, North Carolina, Oregon, and Washington, recognize that BOD_5, TSS, and O&G in effluent in excess of residential strength need to be addressed. No direct correlation exists among the three parameters; therefore they are independent in their role in wastewater and all need to be evaluated to characterize HSW (Matejcek et al., 2000).

Many states chose to define HSW as greater than residential strength. The accepted national definition according to the 2010 CIDWT Decentralized Wastewater Glossary of residential strength wastewater (RSW) effluent from a septic tank or other treatment device is a BOD_5 less than or equal to 170 mg/L, TSS less than or equal to 60 mg/L, and O&G less than or equal to 25 mg/L. HSW is defined as:

1. Influent having BOD_5 greater than 300 mg/L; and/or TSS greater than 200 mg/L; and/or O&G greater than 50 mg/L entering a pretreatment component (as defined by NSF Standard 40 testing protocol);
2. Effluent from a septic tank or other pretreatment component that has BOD_5 greater than 170 mg/L; and/or TSS greater than 60 mg/L; and/or O&G greater than 25 mg/L and is applied to an infiltrative surface.

Conventional OSTS designs for commercial properties are not recommended due to problems and experience with existing systems. Research reports have concluded that high concentrations of BOD_5, TSS, and O&G contribute to increased failure rates in OSTS. Concentrations greater than residential strength of these parameters will cause early failure by creation of a clogging mat in the dispersal component. BOD_5 in excess of 300 mg/L and O&G in excess of 25 mg/L will shorten the life of drainfields, mounds, sand filters, and some aerobic treatment devices without further treatment (Stuth and Garrison, 1997). The impact of O&G has been found to also be substantial; municipal sewer utilities place a discharge limit of 100 mg/L (Farr, 1991 and Stuth and Wecker, 1997). Grease traps are generally considered 60% efficient in removal depending on the form of the oil, presence of surfactants, wastewater temperature, surface area of the gravity separator, and instantaneous flow rate. Treating and breaking down of O&G requires more oxygen and retention time than BOD_5 requires for this treatment to occur.

In a 2000 report by Matejcek et al., four common Floridian soil types were tested in soil columns designed to simulate drainfield conditions. The columns had either a one-foot or two-foot unsaturated zone and each received the same loading rate of approximately 1.2 gal/ft^2. Three synthetic wastewater strengths were applied with the low-strength category being comparable to residential septic tank effluent:

- Low strength mean concentrations – $CBOD_5$ = 99 mg/L, TSS = 48 mg/L, O&G = 13 mg/L
- Medium strength mean concentrations – $CBOD_5$ = 308, TSS = 112 mg/L, O&G = 31 mg/L
- High strength mean concentrations – $CBOD_5$ = 640 mg/L, TSS = 164 mg/L, O&G = 50 mg/L

The columns were dosed twice a day with synthetic wastewater effluent, once in the morning and again in the evening. No failures were recorded with low strength wastewater, which received a daily mass loading of 0.0015 lb/ft^2/day or less. Columns dosed with medium and high strength failed during the same time period with no lag period between the two strengths. It was concluded that the combination of effluent concentrations and hydraulic loading caused formation of a thick clogging mat which resulted in failure.

Challenges associated with treating commercial sewage include:

1. High organic and nitrogen strength,
2. Highly variable diurnal and seasonal flows,
3. Use of chemicals including disinfectants, degreasers, and floor strippers, and
4. Frequent change in management and untrained employees.

These challenges result in many design issues. A significant concern is having enough oxygen to treat or break down the O&G. Another challenge is making sure the pH is high enough to assure that most microorganisms are able to survive. Microorganisms are essential throughout the wastewater treatment process. As the use, seasons, menus and employees change, and with more chemical use for sanitation purposes, the wastewater becomes more and more difficult to predict (Crites and Tchobanoglous, 1998). With these known challenges, regulators and designers of OSTS are often left to do extensive research to find solutions; resulting in systems being installed which have not been field tested.

Pretreatment of HSW utilizing currently available aerobic treatment units, sequencing batch reactors and other commercially available treatment systems can reduce BOD_5, TSS and O&G to concentrations similar to residential waste strength (RSW) or even cleaner. When employed successfully the resulting soil treatment systems can be sized at approximately one-third of that required to treat HSW using organic loading alone. The typical aerobic treatment plant can achieve a 95% O&G removal with an O&G influent of 745 mg/L (Stuth & Wecker, 1997). However, the degree of reduction is individually dependent on the strength of the wastewater, the aeration process, soil properties, system design, use and management of the system and countless other factors.

State regulators have begun requesting verification that pretreatment units can reduce HSW effluent to RSW effluent concentrations. The most commonly used residential treatment unit testing protocol, NSF Standard 40, defines residential strength influent as a BOD_5 of 100 – 300mg/L and a TSS of 100 – 350 mg/L (NSF, 1999). O&G are not addressed in this protocol as it is specific for residential treatment units and therefore cannot be used for HSW testing. EPA in conjunction with the NSF has developed an ETV testing protocol that would allow for HSW testing (NSF, 2000). This field protocol has never been implemented due to many factors. The required field sampling in this protocol is both expensive and difficult to execute. Also, due to the variability in the types of establishments and use the loading to the units is often significantly below or above design. Instead there is movement towards a Standard-HSW, similar to Standard 40. This would standardize a process, so any system designed to treat HSW to RSW, can be tested and certified first. Many issues regarding this Standard-HSW exist and one of the key issues is setting the wastewater characteristics for influent treatment levels.

Literature Review – Characteristics

The definitions of RSW and HSW vary throughout regulations and research. Although BOD_5, TSS and O&G are the common variables used to define the difference between the two wastewaters, other variables unique to many commercial waste streams cannot be ignored in design of OSTS for these facilities.

Organics

There are many sources to estimate the organic loading from the wide range of commercial establishments available from product manufactures and state regulations. The following table has estimates from Goldstein and Moberg (1973) for a wide range of commercial properties.

Estimate of Waste Strengths from Other Establishments		
Type of Facility	BOD (mg/L)	BOD (lbs/unit/day)
Airports		
Per passenger	400 - 500	0.2
Per employee	400 - 500	0.5
Apartment houses	240 - 400	0.175/multiple family
Assembly hall (no kitchen)	240 - 400	0.01/seat
Boarding school	240 - 400	0.15/student
Bowling alley (no kitchen)	240 - 400	0.15/lane
Camps		
Construction (Semi-permantent)	400 - 500	0.140
Counntry club (member)	400 - 500	0.052/member
Country club (resident)	240 - 400	0.208/resident
Day (no meals)	400 - 500	0.031
Luxury	400 - 500	0.208
Church (no kitchen)	240 - 400	0.01/seat
Country club	400 - 800	0.17/member
Personnel addition	240 - 400	0.04/employee
Day school	240 - 400	0.03/student
Add for showers	240 - 400	0.01/student
Add for cafeteria	500 - 700	0.03/meal
Add for employees	240 - 400	0.03/employee
Factory		
No showers	240 - 400	0.04/employee
With showers	240 - 400	0.07/employee
Food service		
Ordinary restaurant	600 - 1500	0.35/seat
24-Hour restaurant	600 - 1500	0.50/seat
Freeway restaurant	600 - 1500	0.70/seat
Tavern (limited food)	400 - 800	0.10/seat
Carry-out (single service)	600 - 800	0.70/100 sqft
Carry-out	200 - 600	0.04/employee
Fast food chain	1000 - 2000	0.80/seat
Hospital (not including personnel)	400 - 600	0.70/bed
Personnel addition	240 - 400	0.04/employee
Laundromat	600 - 800	2.0/machine
Mobile home park	240 - 400	0.40/space
Motel, Hotel	240 - 400	0.30/room
Nursing home (not including kitchen or laundry)	400 - 600	0.30/bed
Personnel addition	240 - 400	0.04/employee
Office building (per 8 hour shift)	240 - 400	0.04/employee
Resort hotel, cottage	240 - 400	0.15/room
Add for self-service laundry	600 - 800	2.0/machine
Service station	240 - 400	0.50/toilet or urinal
Swimming pool	300 - 500	0.21
Shopping center (no food service or laundry)	400 - 600	0.30/1000 sqft
Theaters		
Drive-in	400 - 500	0.010/car space
Indoor	240 - 400	0.010/seat
Travel trailer or RV park		
No water/sewer hook up	400 - 800	0.25/space
With water and sewer	400 - 800	0.30/space

Much of the reported data for OSTS is post grease trap and/or septic tank due to the challenges of collecting raw wastewater samples from these systems. In the literature review by Lowe et al. (2007), the following values for food related HSW effluent were summarized.

Median values for Food Related Establishments (Lowe et al, 2007).

Parameter (mg/L)	**Low**	**High**
BOD_5	561	3,685
TSS	110	4,375

In 2004, a study was published by Lesikar et al., of the characterization of four wastewater parameters (Lesikar et al., 2004) from 28 restaurants located in Texas during June, July, and August 2002. The field sampling methodology included taking a grab sample from each restaurant for 6 consecutive days at approximately the same time each day, followed by a 2-week break, and then sampling again for another 6 consecutive days, for a total of 12 samples per restaurant and 336 total observations. The analysis indicates higher organic (BOD_5) and hydraulic values for restaurants than those typically found in the literature. The values for this study for BOD_5, TSS, FOG, and flow were 1,523, 664, and 197 mg/L, and 96 L/day-seat respectively, which captured over 80% of the data collected.

In a related study by Garza et al., (2005) a statistical evaluation of restaurant management practice and primary cuisine type was evaluated to determine their influence on BOD_5, TSS, O&G, and daily flow. The number of seats in a restaurant, use of self-serve salad bars, and primary cuisine type were found to play a role in the wastewater characteristics.

Matejcek et al., (2000) reported on the physical and chemical characteristics of septic tank effluents from fifteen restaurants using a total of 133 samples collected between May 1997 and March 1999 in Florida. The study began with categorizing into eight categories: restaurants operating less than 16 hours per day, single service restaurants operating less than 16 hours per day, single service restaurants operating more than 16 hours per day, bars and cocktail lounges, drive in restaurants, food outlets, bakeries, and convenience stores. Results show in the following table from the laboratory analyses, varied greatly between sites, restaurant categories and sampling events.

Range in Values for Food Related Establishments (Matejcek et al., 2000).

Parameter	**Low in mg/L**	**High in mg/L**
BOD_5	103	2,820
TSS	40	4,775
O&G	10	300

Analyses showed no detectable levels of toxic organics from cleaning products, nor were any compounds detected that might inhibit anaerobic activity or negatively impact effluent characteristics. The wastewater strength varied between sites by as much as two orders of magnitude. It was concluded that restaurant type or category is a poor indicator of system performance and that the key in determining the size of a restaurant's OSTS are: soil properties, hydraulic loading rate, and mass loading rate.

Another study in Minnesota (Christopherson et al., 2000) evaluated 20 restaurants in 4 categories: fast food, full service, golf club and bar/grill. Each restaurant was sampled 4 times for a total of 80 samples. The HSW effluent mean value ranges are shown below.

Range in Values for Food Related Establishments (Christopherson et al., 2000).

Parameter	**Low in mg/L**	**High in mg/L**
BOD_5	574	1,286
TSS	142	213
O&G	132	282

Farr (1991) investigated the potential cause of a HSW spike at a restaurant in Long Island, NY which had historically been residential strength. The system was found to have a BOD_5 of 355 mg/L and TSS of 243 mg/L and alkaline detergent and grease-cutting enzyme were detected. The author concluded that the impact of O&G and restaurant waste in sewage treatment plants cannot be underestimated and that damage can occur without proper disposal of wastes and greases.

Jantrania (1991) reported restaurant wastewater to be two to three times stronger in BOD_5 with the range of values shown in the following table.

Range in Values for Food Related Establishments (Jantrania, 1991).

Parameter	**Low in mg/L**	**High in mg/L**
BOD_5	1,000	2,000
TSS	300	625
O&G	100	300

The author concluded that OSTS for restaurants should be designed based on the estimated strength, as well as the quantity of wastewater. Additionally, some form of pretreatment is essential for long term performance of the soil absorption systems. Monitoring of HSW OSTS is necessary to provide for changes in business practice and volumes of wastewater. Education of restaurant management and staff is also critical for the systems to be successful.

The Small Scale Waste Management Project published a report which included a preliminary field survey of 42 restaurant wastewater systems along with a comparative study of soil absorption of restaurant wastewater versus household wastewater. After treatment in grease interceptors and multiple septic tanks, restaurant wastewater effluent contained substantial concentrations of BOD_5, TSS, O&G as well as nutrients and bacteria. Septic tank effluent (STE) at supper club type restaurants showed concentrations approximately 380 percent (BOD_5) and 200 percent (TSS) higher than those of household STE (Siegrist et al, 1984). Ranges for effluent concentrations are show in the table below.

Range in Values for Food Related Establishments (Siegrist et al, 1984).

Parameter (mg/L)	Residential	Restaurant
BOD_5	118-189	101 – 880
TSS	41-55	44 – 272
O&G	6.4 – 8.4	24 – 144

Evaluating the literature values provides a very wide range of organic characteristics for commercial properties. In summary, the low and high values are shown in the following table.

Summary of Low and High End of Range of Values for HSW.

Parameter (mg/L)	Low HSW	High HSW
BOD_5	100	3,685
TSS	142	4,375
O&G	50	14,958

It is recommended to use BOD_5 versus $CBOD_5$ as $CBOD_5$ values are 75-95% of BOD_5. This variability is too wide to determine the actual BOD loading. Based on the available data, the following key organic characteristics are recommended for the Standard-HSW, which are in the middle range for HSW:

- BOD_5 = 2,500 mg/l
- TSS = 1,200 mg/l
- O&G = 300 mg/l

The 30-day average organic loading of the wastewater delivered to the system shall be within plus or minus 30% of these values. These values represent the wastewater which will be enter the first component in the treatment train which may be grease trap or septic tank followed by the advanced treatment unit.

Hydraulics

During design of OSTS for HSW facilities the hydraulic loading is critical. In a 2007 literature review by Lowe et al., flow rates from 12 food establishments had significant variability. This was likely due to the inclusion of data from everything from full service restaurants to convenience stores to a quick stop restaurant. The median flow value was 353 gpd, with an average of 814 gpd and a large standard deviation of 1,079 gpd.

Many times, flow estimates are used with commercial properties to estimate the hydraulic flow from the establishment. The following table from MN Rules Chapter 7081 (2008) is one example of flow estimates when actual hydraulic information is not available.

Estimated Sewage Flow from Other Establishments with the Potential for HSW (Gallons/day)		
Dwelling units	**Unit**	**Average daily flow**
Hotel or luxury hotel	guest	55
	square foot	0.28
Motel	guest	38
	square foot	0.33
Rooming house	resident	45
	add for each nonresident meal	3.3
Daycare (no meals)	child	19
Daycare (with meals)	child	23
Dormitory	person	43
Labor camp	person	18
Labor camp (semi permanent)	employee	50
Commercial	Industrial	
Retail store	square foot	0.13
	customer	3.8
	toilet	590
Shopping center	employee	11.5
	square foot	0.15
	parking space	2.5
Office	employee 8-hour shift	18
	square foot	0.18
Medical office*	square foot	1.1
	practitioner	275
	patient	8
Industrial building*	employee 8-hour shift	17.5
	employee 8-hour shift with showers	25
Laundromat	machine	635
	load	52.5
	square foot	2.6
Barber shop*	chair	68
Beauty salon*	station	285
Flea market	nonfood vendor space	15
	limited food vendor space	25
	with food vendor space	50

Dwelling units	Unit	Average daily flow
Eating and drinking establishments		
Restaurant (does not include bar or lounge)	meal without alcoholic drinks	3.5
	meal with alcoholic drinks	8
	seat (open 16 hours or less)	30
	seat (open more than 16 hours)	50
	seat (open 16 hours or less, single service articles)	20
	seat (open more than 16 hours, single service articles)	35
Restaurant (short order)	customer	7
Restaurant (drive- in)	car space	30
Restaurant (carry out including caterers)	square foot	0.5
Institutional meals	meal	5
Food outlet	square foot	0.2
Dining hall	meal	8.5
Coffee shop	customer	7
Cafeteria	customer	2.5
Bar or lounge (no meals)	customer	4.5
	seat	36
Entertainment establishments		
Drive-in theater	car stall	5
Theater	auditorium seat	4.5
Bowling alley	alley	185
Country club	member (no meals)	22
	member (with meals and showers)	118
	member (resident)	86
Fairground and other similar gatherings	visitor	1.5
Stadium	seat	5
Dance hall	person	6
Health club	gym member	35
Outdoor recreation and related lodging facilities		
Campground	person with hook-up	36
	site with hook-up	100
	site without hook-up, with central bath	62
	site to be served by dump station	14.5
Permanent mobile home	mobile home	225
Camp, day without meals	person	20
Camp, day with meals	person	25
Camp, day and night with meals	person	45
Resort	lodge hotel person	62
Cabin, resort	person	50
Retail resort store	customer	4
Park or swimming pool	guest	10
Visitor center	visitor	13

Many commercial establishments have unique flow regimes where large amounts of wastewater are used in a short period of time. Due to the large amount of fluctuations in loading at most facilities producing HSW it is recommended to follow a similar hydraulic loading and schedules as Standard 40 including the stresses of wash-day stress, working parent stress, power/equipment and vacation. Even though most HSW generating facilities will not have these exact stresses they will experience similar shifts in loading, although many treatment systems will utilize time dosing as part of their treatment process which will equalize this flow out over 24 hours. It is still recommended to adjust the design loading to only have 10% of the flow from 6:00 AM to 9:00 AM and add this flow to the 11:00 AM – 2:00 PM and 5:00 PM to 8:00 PM time frame to reflect a larger usage over the lunch and dinner hour for those systems that do not have flow equalization. Therefore the recommended design loading is:

- 6:00 AM – 9:00 AM 10%
- 11:00 AM – 2:00 PM 40%
- 5:00 PM to 8:00 PM 50%

The 30-day average volume of the wastewater delivered to the system shall be within plus or minus 10% of the system's rated hydraulic capacity.

Other Characteristics

Aside from the obvious challenges of organics and hydraulics there are several other characteristics to consider with HSW. The amount of total nitrogen in effluent impacts the treatment process in systems designed to treat HSW. A majority of the nitrogen in the effluent from a septic tank is in the form of ammonium. This ammonium will consume additional oxygen during an aerobic treatment process while being transformed into nitrate. It is recommended that the total nitrogen levels in the HSW wastewater mimic the typical medium level in residential wastewater of 40 mg/L (Tchobanoglous & Burton, 1991) with a 10% tolerance.

With HSW generating facilities there are potential negative impacts on pH and ammonia because of cleaning chemical usage. The wastewater from this study will have a neutral pH of 7 plus or minus 1.

Temperatures can be increased in wastewater from restaurants with high temperature dish washers potentially resulting in decreased retention and therefore elevated O&G levels exiting tanks if not accounted for in design. The wastewater in this study will be at 68 degrees Fahrenheit plus or minus 5 degrees.

Wastewater from food establishments has been found to have high levels of fatty acids as well as nonylphenol (Lowe et al., 2007). The nonylphenols are man-made products of industrial synthesis, particularly polyethoxylate detergents. These acids and chemicals will not be evaluated during this study.

Literature Review – Laboratory Development of Wastewater

Pepples and Mancl (1998) did document diluting raw wastewater to obtain wastewater with residential strength characteristics, but develop of HSW is more complicated than adding water and nitrogen. There is only one published paper available documenting the creation of synthetic HSW (Matejcek et al., 2000). The authors generated synthetic HSW starting with tap water that was allowed to dechloriante over 4 days. Then SPAM ®, Crisco® Vegetable Oil, Purina® Brand Dog Food and dextrose were added along with sludge from a wastewater treatment plant. SPAM® was the primary source for BOD_5 and O&G with dextrose added for minor adjustment to the BOD_5. Dog food was the major contributor to TSS in the synthetic mixture. The sludge was the source for natural bacteria. Batches were mixed from low strength to high strength as described previously.

It is recommended that instead of starting with water and seeding bacteria from sludge to instead start with raw wastewater to more closely resemble natural HSW. It is then suggested to follow the procedures outlined and add SPAM®, vegetable oil, dextrose, and dog food.

The fat found in OSTS is animal based while the oil is from vegetable and cooking oils. There is no literature available evaluating the ratio of oil to fat levels in HSW. Based on the varying melting points and densities of cooking fat and oils shown in the table below it is recommended that both a shortening based product and a vegetable oil product be added to the raw residential sewage. In this case, the fat will come from the Spam® and the oil will come from the vegetable oil.

Cooking fat and oil physical properties (Handbook of Food Science, 2006)

Substance	**Melting Point (^{o}F)**	**Density (g/mL) @ 59-68 (^{o}F)**
Corn oil	12	0.923
Olive oil	32	0.918
Vegetable oil	Na	0.910
Canola oil	14	0.920
Shortening	115	Na
Lard	86	0.919

There was a considerable difference between the target values and actual influent concentrations of O&G for the medium and high strength synthetic wastewater in the study. Starting with a natural wastewater source and following the developed mixing techniques will both be important steps in achieving the organic wastewater characteristics.

Conclusions

This review summarizes the literature on the topic of high strength wastewater and to some extent its effects on OSTS. The purpose of this review is to begin to define some of the characteristics for a Standard-HSW testing protocol and the related laboratory procedures to develop wastewater for implementation of the Standard-HSW.

Therefore the following Standard-HSW organic characteristics are recommended:

- BOD_5 = 2,500 mg/l (+ or – 750 mg/L)
- TSS = 1200 mg/l (+ or – 360 mg/L)
- O&G = 300 mg/l (+ or – 90 mg/L)

To achieve this Standard-HSW it is recommended to start with raw residential wastewater and add SPAM®, vegetable oil, dextrose, and possible milk or a high quality dog food. The laboratory development will start with the SPAM®, vegetable oil, dextrose and evaluate if milk or dog food is needed. This results in a ratio of BOD_5 : TSS : O&G of 8.3 : 4.0 : 1.

Recommendations

In order for this Standard-HSW to move forward, general agreement from the interested parties is needed on the concept and loading including both organic and hydraulic. The ETV HSW committee will be a valid group to consult for this discussion.

Future Work

Laboratory work has begun manufacturing the HSW in a laboratory setting. The initial procedure involve mixing Crisco®, dextrose, Purina ® dog food, dry milk, and Spam® with raw wastewater supplied by the Metropolitan Wastewater Treatment Plant in St Paul, MN. The current procedure involves:

1. Raw wastewater is kept in cold room storage and collected weekly from the plant.
2. Depending on the batch size being generated, 500-1000 ml of wastewater is used as starting base.
3. The pH is measured and adjusted with acid until wastewater is at or near a pH of 7.
4. Approximately 100 mL of wastewater is heated on a hot plate.
5. Solid ingredients are measure and recorded.
6. Hot wastewater is used to dissolve the dextrose, Crisco®, and Spam®.
7. The Spam® is also crushed with spoon or finger.

8. All ingredients and wastewater is placed in the blender and processed for approximately 5 minutes.
9. Samples are then analyzed for Biochemical Oxygen Demand (EPA Method 405.1), Total Suspended Solids, (EPA Method 160.2), Oil and Grease (EPA Method 1664).

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