WASHINGTON STATE DEPARTMENT OF HEALTH

Rule Development Committee Issue Research Report - Draft

Wastewater Quality / Strength / Content

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- Definitions ☐

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Topic & Issues:

WASTEWATER QUALITY/STRENGTH/CONTENT

- What numerical values can be derived to define "Residential Strength Wastewater " for determining whether a particular source is typical domestic strength?
- What numerical values can be derived to define "High Strength Wastewater" for determining whether a particular source is higher than domestic strength?
- Is there an existing testing protocol that can be placed into rule for High Strength Wastewater treatment systems or does one need to be developed?
- What are the system design criteria needed to address High Strength Wastewater? Explore the use of appropriate design standards.
- Clarify the permitting of nonresidential waste streams and design requirements of nonresidential sources; e.g. dog kennels, restaurants, mini mart, etc.

Summary:

This report summarizes the literature on the topic of high strength wastewater and it's effects on on-site sewage systems. The purpose of this report is to review the literature available on the topic of high strength wastewater in order to determine the need to better define residential strength wastewater, to define high strength wastewater, possible alternative design criteria, and the capacity of these alternative designs to reduce high strength wastewater parameters.

This review was undertaken because application of high strength wastewater has been attributed to severe soil clogging to the point of hydraulic failure, anoxic soil conditions, and reduced wastewater treatment. The accelerated rate of failures on commercial sites has led researchers to explore the cause of such failures. High concentrations of biochemical oxygen demand (BOD_5), total suspended solids (TSS), and fats, oils, and greases (FOG) were indicative of these failures. The lack of clear guidance for determining and evaluating high strength wastewater has brought about a need for research in this area, however the research available is still quite limited.

Design of on-site sewage systems currently is based on hydraulic loading rates and soil acceptance rates. Hydraulic loading rates do not take into consideration the organic loading to the soil. Septic tank effluent when applied to the soil causes a clogging layer to form. This clogging layer is also known as a biomat. The clogging layer, while increasing treatment performance, reduces the infiltrative capacity of the soil.

Soil clogging is generally accelerated under increasing hydraulic loading rates or under increasing concentrations of organic matter and suspended solids.

Most states have not taken high strength wastewater characteristics into consideration when designing on-site sewage disposal systems. However, a number of states such as North Carolina, Oregon and Washington are now recognizing that effluent BOD_5, TSS, and FOG concentrations in excess of domestic septic tank effluent may need to be addressed. A number of pretreatment possibilities exist. To what extent these pretreatment alternatives reduce high strength wastewater is yet to be completely understood. The Environmental Protection Agency (EPA) and National Sanitation Foundation, International (NSF) have recently completed a testing protocol that may assist in determining treatment capacity of these pretreatment alternatives.

KEYWORDS: *(commercial wastewater, high strength wastewater, grease and oil, mass loading rate, organic loading, residential strength wastewater, restaurant, soil clogging)*

Introduction: Hydraulic loading and treatment performance have been the basis for design of on-site sewage disposal systems in this state. Treatment standards are in place specifically to address repairs and reductions in vertical and horizontal separation. These standards include limits for BOD_5, TSS, and fecal coliform. Current practice does not require consideration of biological or organic loading when designing a “conforming” system. For non-residential sewage, the rules do however require the designer to provide information to establish the sewage strength and identify chemicals found in the sewage that are not found in residential sewage.

Research reports have concluded that high concentrations of BOD_5, TSS, and FOG will contribute to increased failure rates. Concentrations greater than residential strength of these parameters will cause early failure by creation of a clogging mat in the dispersal component. When combined, “effluent concentration and hydraulic loading both contribute to clogging and formation of biomat, resulting in failure” (Matejcek, Erlsten & Bloomquist, 2000). Researchers agreed that pretreatment of high strength wastewaters whether commercial or residential must be included in design to reduce these parameters. The definitions of residential strength wastewater and high strength wastewater vary throughout the research. Residential strength wastewater <u>influent</u> examples range from BOD_5 100 mg/L – 400 mg/L, TSS 100 – 400 mg/L, and FOG 50 – 150 mg/L. High strength wastewater influent examples range from BOD_5 100 – 3685 mg/L, TSS 142 – 4375 mg/L, and FOG 25 – 14,958 mg/L. Many of the researchers chose to define high strength wastewaters as “greater than residential strength”. The most commonly used residential strength testing protocol defines residential strength influent as BOD_5 100-300 mg/L, TSS 100-350 mg/L (NSF Standard No. 40). Fats, Oils, and Greases are not addressed in this protocol. The testing protocol is specific for residential treatment units and cannot be used for high strength wastewater testing. The Environmental Protection Agency (EPA) in conjunction with the National Sanitation Foundation (NSF) have developed a testing protocol that would allow for high strength wastewater testing (NSF International, 2000). Although FOG is not included in this testing protocol, it can be added by request of the petitioner.

The purpose of this review is to synthesize the literature available on the topic of high strength wastewater so that the Technical Review Committee can make appropriate recommendations about residential wastewater and high strength wastewater definitions, design requirements, and potential high strength wastewater testing protocols to the Rule Development Committee. More than 35 publications, which include peer, reviewed journal articles, conference proceedings and government reports were collected and reviewed. Even though the majority of the publications are conference proceedings, which are typically not peer reviewed, they provided useful information regarding the high strength wastewater.

Residential Strength Wastewater

In the Washington Administrative Code (WAC), residential wastewater "means sewage having the constituency and strength typical of wastewater of domestic households". The WAC does not however define what those constituents and strengths are to be. The Recommended Standards and Guidance for Aerobic Treatment Units (ATUs) does define residential strength influent (untreated domestic wastewater) in accordance with the National Sanitation Foundation Standard Number 40 as 100-300 mg/L $CBOD_5$ and 100-350 mg/L TSS. FOG is only addressed in the product performance section for Category 2 ATUs (designed to treat high strength non-residential or commercial wastewater) where the performance must provide an effluent (septic tank effluent) quality equal to or less than 200 mg/L BOD_5, 125 mg/L TSS, and 25 mg/L FOG.

Influent: Residential influent (untreated domestic wastewater) parameters range greatly throughout the research with most being consistent with the range provided in the NSF Standard Number 40 protocol. The North Carolina Administrative Code addresses concerns noting that influent shall be similar to domestic sewage with concentrations of BOD_5 and TSS not to exceed 300 parts per million (mg/L). FOG of residential wastewater has not been addressed in most states. However, the effect of FOG on on-site sewage disposal systems has been consistent throughout the literature.

Typical composition of untreated domestic wastewater (influent) was defined by one research group using concentration levels of weak, medium, and strong. Weak, medium, and strong levels of BOD_5 (mg/L) were identified as 110, 220, and 400, concentrations of TSS (mg/L) were identified as 100, 220, and 350, and concentrations of FOG (mg/L) as 50, 100, and 150 respectively (Tchobanoglous and Burton, 1991). Another researcher identified the character of household wastewater using average and maximum levels. Average BOD_5 levels were identified as 200 mg/L with a maximum of 400 mg/L, average TSS levels of 200 mg/L with a maximum of 400 mg/L, and average Grease levels of 50 mg/L with a maximum of 150 mg/L (Laak, 1986).

Most researchers apply a range to quantify concentrations of BOD_5, TSS, and FOG for wastewater influent. The most commonly used range is 100-300 mg/L BOD_5 and 100-350 mg/L TSS (NSF Standard No. 40). FOG ranges typically are identified as 50-150 mg/L with 150 mg/L being identified as "strong".

Effluent: Conventional household septic tank effluent was identified by one researcher as 90-384 mg/L BOD_5, 40-350 mg/L TSS, and 50-150 mg/L Grease (Laak, 1986). However one study within Washington State found effluent concentrations of BOD_5 in excess of 300 mg/L and FOG in excess of 25 mg/L will shorten the life of drainfields, mounds, sandfilters, and some aerobic treatment devices without pretreatment (Stuth, Garrison, 1997). A conventional septic tank removes about 40-50% BOD_5 and 50-70% SS (Laak, 1986). Some counties within the State of Washington have chosen to identify residential wastewater septic tank effluent characteristics. These definitions vary within the state, examples are as follows: <230 mg/L BOD_5, <125 mg/L TSS, < 25 mg/L FOG; 230 mg/L BOD_5, 145 mg/L TSS, 20 mg/L grease and oil; 230 mg/L BOD_5, 250 mg/L TSS; 139 mg/L BOD_5, 71 mg/L TSS, 15 mg/L O&G.

One range for septic tank effluent concentrations showed BOD_5 as 140-200 mg/L and TSS as 50-100 mg/L (Siegrist, 2000). While other researchers have shown ranges of 100-150 mg/L BOD_5, 40-140 mg/L TSS, and 20-50 mg/L FOG (Crites & Tchobanoglous, 1998). They expanded their research to include ranges for effluent concentrations using effluent filters, 100-140 mg/L BOD_5, 20-55 mg/L TSS, and 10-20 mg/L FOG (Crites & Tchobanoglous, 1998).

Most researchers apply a range of concentrations of BOD_5, TSS, and FOG typically identified as septic tank effluent.

High strength wastewater

High strength wastewater has been identified as a cause of early failure of on-site sewage disposal systems. High daily mass loading rate is a direct cause of drainfield failure (Matejcek, Erlsten, & Bloomquist, 2000). Soil clogging is generally accelerated under increasing hydraulic loading rates of a given wastewater effluent, or under increasing concentrations of organic matter and suspended solids at a given hydraulic loading rate (Siegrist, 1987). The formation of the biomat is a function of wastewater loading whereby increasing the organic loading tends to accelerate the biomat growth (Amoozegar, 1998). Concentrations of tBOD (total BOD) and TSS in restaurant septic tank effluent typically are more than 200% higher than those of domestic septic tank effluent (Siegrist, 1987). The mass density loadings of tBOD (total BOD) and TSS appear to be key determinants of soil clogging development and system design should account for this fact (Siegrist, 1987). Limits should be established for restaurant effluent concentrations to be in the low wastewater strength category (similar concentrations to that of waste from domestic systems) (Matejcek, Erlsten & Bloomquist, 2000).

It has also been noted that soil properties vary as to their ability to treat high strength wastewater. Silty sands are particularly sensitive to BOD_5 overloading, however soil types 3 through 5 can handle a maximum BOD_5 of 230 mg/L (Stuth, 1992). Two studies in Florida found a mass loading rate threshold between .0015 lb/ft^2/day and .0024 lb/ft^2/day BOD_5 for the soils tested (Matejcek, Erlsten, Bloomquist, 2000, Erlsten & Bloomquist, 2001). Drainfield sizing should include mass loading rates and hydraulic loading rates based upon soil properties (Matejcek, Erlsten, Bloomquist, 2000).

Researchers agree that monitoring of high strength wastewater allows for early detection of problems in order to take remedial actions (Jantrania, Siegrist, 1984, Stuth, 1989, Stuth, 1994). Regular maintenance of septic tanks prevent failure of the drainfield due to clogging and protects surface and ground water from nutrients, pathogens and other contaminants by preventing backups and overflows (Russell, 2002). Restaurants producing high levels of grease and oils or high BOD_5 need to provide pre-treatment of the effluent prior to disposal. These types of establishments must be monitored and managed by competent professionals. It is important that the monitoring program be on going to provide for the changes in business practices or volumes as they occur (Kommalapati, Johnson, 2001). The greatest challenge encountered when monitoring commercial on-site systems is having the ability to guarantee an ongoing monitoring program (Stuth, 1999). Costs to repair or replace the system are far in excess of the costs of monitoring (Stuth, 1999).

There is a lack of research data for Fats, Oils, and Greases, however in each research paper reviewed FOG was a characteristic that would cause clogging of the drainfield. The impact of grease in sewage cannot be underestimated (Farr, 1991). BOD_5 in excess of 300 mg/L and FOG in excess of 25 mg/L would shorten the life of drainfields, mounds, sandfilters, and some aerobic treatment devices without pretreatment (Stuth and Garrison, 1997). Typically the municipal sewer utilities place a discharge limit of 100 mg/L FOG regardless of origin (Stuth & Wecker, 1997). Residential strength waste is generally believed to have a FOG level in the low 20's (mg/L) (Stuth & Wecker, 1997).

The treatment of commercial waste containing FOG, normally from a food service establishment, has three challenges: 1) having enough oxygen to treat or break down the FOG, 2) making sure the pH is high enough to assure that most microorganisms are able to survive, and 3) guarantee that there is an ongoing monitoring program in place (Stuth, 1989). FOG levels within the research have been documented as high as 15,000 mg/L.

Definitions for high strength wastewater vary significantly. Minimum values begin as low as 100 mg/L BOD_5, 65 mg/L TSS, and 25 mg/L FOG. No correlation was determined among the three parameters, suggesting that all three are required to characterize effluent (Matejcek, Erlsten, Bloomquist, 2000).

The Washington Administrative Code addresses proposals for the use of on-site sewage systems for non-residential sewage (WAC 246-272-11501(3)). The WAC requires that the designer provide information to establish the sewage's strength and identify chemicals found in the sewage that are not found in residential sewage and a design providing treatment equal to that required of residential sewage. The WAC again does not define what those constituents and strengths are to be. Effluent sampling for repair of on-site sewage systems provides effluent concentration information to assist in design, however designs for new construction must also provide information to establish the sewage's strength and a design providing treatment equal to residential sewage. The expected influent concentrations supplied by the designer are used to determine the need for pretreatment, however representative influent samples are very difficult to obtain. Average concentrations of pollutants from plumbing fixtures can be found in research and may provide assistance to the designer in determining potential influent characteristics (Laak, 1986).

Pretreatment Design Criteria

Pretreatment devices to be used also varied throughout the research, however some form of pretreatment of restaurant wastewater is essential for better performance and a longer life of soil absorption systems (Jantania). Grease traps or Grease Interceptors have historically been the pretreatment component of on-site sewage disposal systems serving restaurants. Increased detention time of 2-3 days has been considered adequate for pretreatment. However, research has shown that even after treatment in grease interceptors and multiple septic tanks, restaurant wastewater effluent still contains substantial concentrations of biodegradable organic materials, suspended solids, grease, as well as nutrients and bacteria (Siegrist, Anderson, Converse, 1984). A two or three day retention time along with filters does not reduce the FOG enough to prevent damage to the drainfield (Stuth, 1989). One commercially available grease-trap effluent filter was found to reduce SS by 27-57% and O&G by 44-52% noting that future studies need to be conducted to determine the specific mechanisms causing these reductions (Wong, Ngie-Hing, 1998).

Undersized grease traps with inadequate detention capacity are of limited value in removing FOG (Stuth, 1989). Recent developments in micro-processor-based ultrasonic technology can assist in continuous monitoring of grease, sludge, liquid level and temperature in tanks alerting the owner that it is time to pump the tank. Even with automatic monitoring systems in place, owner awareness, managed maintenance and regulatory oversight are important to ensure the future of improved wastewater treatment and the environment (Russell, 2002).

Grease traps may assist with reducing the FOG concentration with an increased detention time of four days or greater however without further pretreatment the effluent can still contain substantial concentrations of BOD_5, TSS, and FOG (Siegrist, 1984). Pretreatment of restaurant effluent utilizing currently available aerobic treatment units, sequencing batch reactors and other commercially available treatment systems would reduce $CBOD_5$ and TSS in the effluent to concentrations similar to domestic waste strength (Matejcek, Erlsten, & Bloomquist, 2000).

Previous research has shown that recirculating gravel filters may assist with treating light commercial strength wastewater as long as the BOD_5 does not exceed 720 mg/L (DOH, 2000). Intermittent sand filters are mentioned throughout the literature as a possible pretreatment alternative. Earlier research by DOH however showed that pretreatment prior to intermittent sand filters is needed to reduce the strength to less than 220 mg/L BOD_5 and less than 145 mg/L TSS (DOH, 2000).

FOG requires more oxygen to break down than BOD_5 (Stuth). The typical aerobic treatment plant can achieve a 95% FOG removal with an influent of 745 mg/L (Stuth & Wecker, 1997). Most researchers agreed that aerobic pretreatment is able to reduce high strength wastewater. However, the degree of reduction is individually dependent on the strength of the wastewater and the aeration process.

The Environmental Technology Verification Program was established by the USEPA to evaluate the performance of innovative and commercially available environmental technologies. Technologies eligible for evaluation under this protocol include all technologies for the decentralized treatment of non-residential wastewater (commercial or industrial), in addition to residential wastewater treatment technologies with a design average flow of greater than 1,500 gallons per day (NSF International, 2000). The verification testing period is a minimum of twelve consecutive months and include all seasons, with no more than 10% upset conditions or downtime (approximately 36 days). The Protocol for the Verification of Wastewater Treatment Technologies is the only currently available, national recognized testing protocol for non-residential wastewater treatment technologies.

Non-residential Waste Streams (Dog kennels, restaurants, mini-marts, etc.)

Animal Waste: In this state, waste from animal operations are included in the definition of Industrial Wastewater and are the jurisdiction of the Department of Ecology, 173-216 WAC. The Department of Ecology in Eastern Washington has outlined design considerations for waste from animal operations. However verbal reports from local health staff in Western Washington show that local health jurisdictions lack clear guidance from the Department of Ecology and consistently must make determinations outside of their jurisdiction without technical assistance from DOE.

Restaurants categories, mini-marts, etc.: One recent study in Florida concluded that restaurant type or category is a poor indicator of system performance and that the following factors should be used in determining the size of a restaurant's on-site drainfield: soil properties, hydraulic loading rate, and mass loading rate. (Matejcek, Erlsten, & Bloomquist, 2000). Effluent quality of restaurants may have 2.8 times the concentration of biochemical oxygen demand (BOD_5) and total suspended solids (TSS) compared to domestic systems (Siegrist et al., 1984). The study in Florida began with categorizing restaurants in 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, finding that wastewater strength varied between sites by as much as two orders of magnitude (Matejcek, Erlsten, & Bloomquist,2000).

Cost Information: Cost of repair due to premature failure. Pretreatment will increase the cost initially (pretreatment unit and on-going operation and maintenance) but should be offset by reduced failure incidence. Failures due to high strength wastewater have been shown to occur within weeks of installation. Pretreatment with on-going operation and maintenance has been shown to extend the life of service.

Conclusions:

- High strength wastewater (in excess of residential strength) will cause premature failure.
- Limits should be established for restaurant effluent concentrations to be similar to concentrations of residential strength wastewater.
- Soil organic loading rates should be taken into account when treating high strength wastewater.
- The EPA ETV testing program is the only nationally recognized testing protocol currently available for high strength wastewater pretreatment technologies.
- Grease traps with 2-3 days detention time do not adequately pretreat high strength wastewater.
- Monitoring of high strength wastewater sites will increase the life of the on-site sewage disposal system.
- Animal operations are under the jurisdiction of the Department of Ecology. Statewide design standards are needed to assist local health.

Recommendations

- **What numerical values can be derived to define "Residential Strength Wastewater " for determining whether a particular source is typical domestic strength?**

- Define maximum influent (untreated domestic wastewater) parameters of residential strength wastewater as 300 mg/L BOD_5, 350 mg/L TSS, (NSF Standard Number 40) and 100 mg/L FOG.

- **What numerical values can be derived to define "High Strength Wastewater" for determining whether a particular source is higher than domestic strength?**

- Define high strength wastewater as higher than residential strength influent.

- **Is there an existing testing protocol that can be placed into rule for High Strength Wastewater treatment systems or does one need to be developed?**

- Require EPA's ETV testing protocol to be used for pretreatment technology verification and to include BOD_5, TSS, and FOG.

- **What are the system design criteria needed to address High Strength Wastewater? Explore the use of appropriate design standards.**

- Require proven (ETV) pretreatment of high strength wastewater.
- Require monitoring of high strength wastewater sites.

- **Clarify the permitting of nonresidential waste streams and design requirements of nonresidential sources; e.g. dog kennels, restaurants, mini mart, etc**

- Animal operations are under the jurisdiction of the Department of Ecology. Statewide design standards are needed to assist local health.
- Additional research needed.

References:

Amoozegar A., and Niewoehner, C.P., 1998. Soil Hydraulic Properties Affected by Various Components of Domestic Wastewater, On-Site Wastewater Treatment: Proceedings of the Eight National Symposium On Individual and Small Community Sewage Systems, ASAE, St. Joseph, MI. p.155-166.

> Hydraulic failure of a septic system may be attributed to the formation of a biomat in its trenches, but the chemical composition of wastewater may also significantly contribute to the failure of the system. The effects of various components of domestic wastewater on the hydraulic properties of three soils were studied. The soils were a sandy soil, the clayey Bt horizon of a soil, and a commonly occurring saprolite (C horizon) from North Carolina. Saturated hydraulic conductivity (K_{sat}) and infiltration rate (IR) of the soils and saprolite for tap water, simulated wastewaters from a washing machine, kitchen sink, bathroom sink and shower, and car wash with a water softener were measured in situ for five consecutive days using three replications. The simulated wastewaters affected the K_{sat} and IR differently. Simulated wastewater from a laundry machine

had the most deleterious impact on soil hydraulic properties. In some cases, application of a $CaCl_2$ solution to the soil resulted in restoration of infiltration rate and hydraulic conductivity.

Angola T., 1998. Onsite Wastewater Treatment for Funeral Homes, Small Flows Quarterly, Fall 1998, Vol. 12, No. 4, pg. 13.

Angola T., 2000. The Best Wastewater Systems Consider Flow Rate and Waste Strength, Small Flows Quarterly, Spring 2000, Vol.1, No. 2, pg. 14.

This article explains the importance of designing wastewater systems based on both flow (gpd) and wastewater strength.

Brown D.F., Jones L.A., Wood, L.S., 1994. A Pedologic Approach for Siting Wastewater Systems in Delaware, Proceedings of the 7th International Symposium on Individual & Small Community Sewage Systems, 1994, pg. 229.

This paper discusses the importance of using soil science versus percolation tests when siting on-site sewage disposal systems.

Christopherson S.H., Gustafson D., Anderson J., 2000. Evaluation of Restaurant Waste Strength, 2000.

This paper evaluates 20 restaurants in 4 categories, fast food, full service, golf club, and bar to determine compliance with Minnesota Rules Chapter 7080 requiring limits of 200 mg/l BOD_5, 65 mg/L TSS, and 30 mg/L FOG. Wastewater exceeding these limits must have pretreatment. All 20 restaurants exceeded these limits with mean ranges of BOD_5 574 – 1286 mg/L, TSS 142 – 213 mg/L, and FOG 132 – 282 mg/L.

Crites, R, Tchobanoglous, G, 1998, Small and Decentralized Wastewater Management Systems, McGraw-Hill Series in Water Resources and Environmental Engineering, 1998, pg. 178-182.

Eddy, N. 1998. Restaurants and Commercial Facilities Present Specific Problems for Onsite Systems, Small Flows, Spring 1998, Vol. 12, No. 2, pg. 1,4,& 5.

This article focuses on how restaurants and other commercial facilities can prevent grease from clogging an onsite system's leachfield by using grease traps.

Erlsten, S, Bloomquist, D, 2001, Long Term Acceptance Rates of Common Floridian Soils, Department of Civil & Coastal Engineering, University of Florida, 2001. 166 pages.

This study is Phase 3 of a series of studies performed in the state of Florida. Phase3 confirms that the mass loading threshold of the 4 soil types studied in Phase 2 (Matejcek, B, Erlsten, S, Bloomquist, D, 2000) lies between .0015 $lb/ft^2/day$ and .0024 $lb/ft^2/day$. This study also included dissecting the lysimeters in Phase 2 wherein it was found that the differences between medium-strength and high-strength wastes were barely noticeable despite the high-strength lysimeters having received substantially more mass.

Farr, JW, 1991. The effect of restaurant wastes on a small system, Journal of Environmental Health, March-April 1991, pg. 45.

This article documented an investigation of the potential cause of a high strength wastewater spike at a restaurant in Long Island, NY which had historically been residential strength. Surface water discharge into an active shell-fishing area was the means of final disposal.

Indicators of investigation:
BOD_5 = 355 mg/L
TSS = 243 mg/L
Chlorine demand 13.4 ppm

Potential causes:
Alkaline detergent
Grease-cutting enzyme

Corrections:
Use of less alkaline detergent
Discontinue use of enzyme
Increase frequency of pumping grease trap

The author concluded that the impact of grease and restaurant waste in sewage treatment plants cannot be underestimated. Damage can occur without proper disposal of wastes and greases.

Haffner, R., 2000, Small Wastewater Treatment Systems Consensus Standards

Jantrania, A., 1991, Dealing with Oil and Grease in Restaurant Wastewater, Small Flows Journal, Vol. 5, No. 1, January 1991. 5 pages.

This study reported restaurant wastewater to be two to three times stronger in BOD_5 than domestic wastewater. With reference to additional studies showing BOD_5 levels of 1,000 to 2,000 mg/L, TSS concentrations of 300 to 625 mg/L, and FOG of 100 to 300 mg/L.

Conclusion: Onsite treatment and disposal systems for restaurants should be designed based on the estimated strength, as well as the quantity of wastewater. Some form of pretreatment of restaurant wastewater is also essential for better performance and a longer life of soil absorption systems. Monitoring of onsite systems is necessary to provide for changes in business practice or volumes as they occur. Education of restaurant management and staff is also a critical part of a successful onsite wastewater system.

Jeter, W, 2001, Memorandum: Innovative Wastewater Treatment System Verification, North Carolina Department of Environment and Natural Resources, April 2001.

One of the principal parameters used in wastewater system design is the hydraulic loading rate The North Carolina Department of Environment and Natural Resources has given allowance for the use of two new testing protocols for non-domestic wastewater treatment, nutrient removal, and pathogen reduction. This memorandum states that to "aid in the assurance that representative data is submitted, system vendors requesting Innovative Approval beyond the scope of NSF Standard 40 Class I may use either of the following verification protocols to support their request:

1. "Protocol for the Verification of Residential Wastewater Treatment Technologies for Nutrient Reduction", NSF-ETV, November 27, 2000.

2. "Protocol for the Verification of Wastewater Treatment Technologies", NSF-ETV, April 2001.

Kommalapati, R, Johnson, R, 2001, A Literature Review on the Evaluation of Design Parameters for Modern Grease Traps and High Strength Wastes, Texas On-Site Wastewater Treatment Research Council, April, 2001. pp. 1-24.

This paper is a literature review predominantly focused on grease trap design. Limited literature resulted in conclusions that education of restaurant owners was key to protecting drainfields, restaurant on-site sewage disposal systems should be designed for the estimated waste strength as well as effluent quantity, and that pretreatment systems such as automatic removal systems or biological pretreatment units could provide effective treatment for wastewater before it enters the septic tanks. While education of restaurant personnel may be very effective and has the most advantages from the standpoint of cost, it is perhaps the least reliable method due to high personnel turnover in restaurants.

Establishments with limited food preparation and which have effluent strength similar to residential effluent need no special treatment other than periodic monitoring. Restaurants producing high levels of grease and oils or high BOD_5 need to provide pre-treatment of the effluent prior to disposal. These types of establishments must be monitored and managed by competent professionals. It is important that the monitoring program be on going to provide for the changes in business practices or volumes as they occur.

Kennedy, Jenks, Chilton, 1989, Study Report of Arco AM/PM Mini-Market Sewage Quantity and Quality Versus Domestic Quantity and Quality, June 1989. 20 pages.

Laak, R, 1986, Wastewater Engineering Design for Unsewered Areas, Second Edition, p. 23.

Matejcek, B, Erlsten, S, Bloomquist, D, 2000, Determination of Properties and Long Term Acceptance Rate of Effluents from Food Service Establishments that Employ Onsite Sewage Treatment, Department of Environmental Engineering Sciences and Civil & Coastal Engineering, University of Florida, 2000. 167 pages.

This study 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. Four common Floridian soil types were tested in soil columns designed to simulate drainfield conditions. Three wastewater strengths were applied with the low-strength category being comparable to residential septic tank effluent. No failures were recorded in lysimeters 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. Twenty of the two-foot unsaturated column (eleven medium strength and nine high strength) and four of the one-foot unsaturated columns (two medium strength and two high strength) failed in the 112 days of experimentation. Eighteen of the two-foot unsaturated lysimeters failed between 20 days and 47 days from the start of dosing.

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

No correlation was determined among the three tests (BOD_5, TSS, and FOG), suggesting that all three analyses are required to characterize effluent. The study also indicated that restaurant type or category was a poor indicator of system performance.

While the report suggested that drainfield sizing should include mass loading rates and hydraulic loading rates based upon soil properties, there appeared to be an inverse relationship between high strength and medium strength wastewater with respect to loading rates and soil type. Failure in the Candler columns (1.2 gpd/ft^t) was more rapid with the medium strength wastewater than with the high strength. Failure in the Pomona with Candler Fill columns (0.65 gpd/ft^2) was more rapid with the high strength wastewater than with the medium strength. Days to failure in the Millhopper (0.9 gpd/ft^2) for both wastewater strengths overlapped during the same relative time period.

North Carolina Administrative Code, 1999, Title 15A, Subchapter 18A, Section 1957. pp. 30-36.

The 1999 North Carolina Administrative Code restricts the use of aerobic sewage treatment units (ATUs) on high strength wastewater sites. "ATUs shall not be used, however, where wastes contain high amount of grease and oil, including restaurants and food service facilities. The strength of the influent wastewater shall be similar to domestic sewage with Biological Oxygen Demand (BOD) and suspended solids not to exceed 300 parts per million."

National Sanitation Foundation, International, 1999, Residential Wastewater Treatment Systems, ANSI/NSF 40 - 1999.

National Sanitation Foundation, International, 2000, Protocol for the Verification of Wastewater Treatment Technologies, April 2000.

This generic protocol was developed to be employed for the verification testing of commercially available, prefabricated technologies for the decentralized treatment of wastewater. Technologies eligible for evaluation under this protocol include all technologies for the decentralized treatment of non-residential wastewater (commercial or industrial), in addition to residential wastewater treatment technologies with a design average flow of greater than 1,500 gallons per day (gpd).

The Environmental Technology Verification (ETV) Program was established by the USEPA and is intended to:

1. Evaluate the performance of innovative and commercially available environmental technologies
2. Provide permit writers, buyers and users, among other, with objective information about technology performance
3. Facilitate "real world" implementation of promising technologies

The objective of verification testing shall be to determine the following:

1. The performance of a specific wastewater treatment technology relative to the Vendor's stated range of technology capabilities, operating under field conditions
2. The necessary inputs (power, chemicals, labor, etc.) and the operating costs of the technology
3. The range of operating conditions and the ease of operation and maintenance of the equipment
4. The effect of the equipment operating cycle, including start-up, dynamic operation, and shutdown on treatment performance, and operational and maintenance performance

Verification Testing Period:
The verification testing period shall run a minimum of twelve consecutive months and include all seasons, with no more than 10% upset conditions or downtime (approximately 36 days).

Analytical Sampling Frequency:
Analytical sampling for Verification Testing shall occur under average, peak-day, and minimum flow conditions with at least one-third of samples taken during average flow conditions and one-third during peak-flow conditions.

Biological – Monthly: Minimum of 12 four-day sampling periods, one each month, at least ten days between sampling events

Supplemental: Minimum of 4 four-day sampling periods to be schedule at the discretion of the Testing Organization.
Non-Biological – Minimum of 12 four-day sampling periods.
Core sampling parameters include pH, Temperature, TSS (mg/L), $CBOD_5$ (mg/L), COD (mg/L).
Supplemental parameters can also be tested to verify Vendor-specified target constituents (eg. FOG, TKN, Fecal Coliform, etc.).

Oregon Administrative Rules, 2000, Chapter 340, Division 071.

Defines Residential Strength Wastewater as the primary sewage effluent from a septic tank which does not typically exceed the following parameters: Five-Day Biochemical Oxygen Demand (BOD_5) of 300 mg/L; Total Suspended Solids (TSS) of 150 mg/L; Total Kjeldahl Nitrogen (TKN) of 150 mg/L; and Oil and Grease of 25 mg/L. Other contaminants may also be present in the wastewater, however, they shall not exceed the concentrations or quantities normally found in residential sewage. Effluent parameters are to be measured using approved Standard Method or EPA procedures.

Russell, J, 2002, Cutting Grease With Ongoing Monitoring and Maintenance, Wastewater Engineering & Management, March 2002. pp. 16 – 21.

This paper focuses on monitoring and maintenance of grease in wastewater using micro-processor-based ultrasonic technology specifically designed for septic tanks and grease traps.

Siegrist, RL, Anderson, DL, Converse, JC, 1984, Commercial Wastewater On-Site Treatment and Disposal, On-Site Wastewater Treatment Proceedings, December 1984. pp. 210 –219.

Siegrist, RD, Anderson, DL, Converse, JC, 1984. Onsite Treatment and Disposal of Restaurant Wastewater, Small Scale Waste Management Project, University of Wisconsin, April 1984. 38 pages.

The overall objective of this work was to investigate the design and performance of septic tank-soil absorption systems for restaurant wastewaters. The specific objectives were to:

1. Identify the current design practice utilized for restaurant systems,
2. Characterize restaurant septic tank effluent in terms of daily flow and composition,
3. Determine the operation status and infiltration capacity of a sample of restaurant soil absorption systems,
4. Compare the infiltration and purification through soil of restaurant septic tank effluent versus household septic tank effluent, and
5. Develop modifications as appropriate to presently used design practice to facilitate successful performance of restaurant systems.

A preliminary field survey of 42 restaurant wastewater systems occurred during 1982 followed by a detailed investigation of 12 systems during 1983. A comparative study of soil absorption of restaurant wastewater versus household wastewater was conducted under laboratory conditions between July and December 1983.
Even after treatment in grease interceptors and multiple septic tanks, restaurant wastewater effluent contained substantial concentrations of biodegradable organic materials, suspended solids, grease 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.

Authors' recommendations:

1. Efforts should be made to educate the managers of restaurant establishments regarding appropriate interior water us and waste disposal habits, proper use of cleansers and additives, and systems operation requirements.
2. Flow monitoring equipment (e.g. water meters) should be included in commercial facilities such as restaurant establishments. Flow data is essential to proper system operation and management and to interpretation of system performance.
3. Separate septic tank facilities should be used for pretreatment of the kitchen waste stream only. The effluent from these facilities should enter the main building sewer prior to its entry to the remaining septic tanks.
4. Septic tank treatment should consist of three or more tanks in series. The tanks should be pumped quarterly during the initial period of operation until the rate of sludge and scum accumulation is known at which time an appropriate pumping schedule can be established.
5. For restaurant subsurface wastewater absorption systems of bed geometry installed in soils of sand texture, maximum loading rates for STE of approximately 0.70 gpd/ft^2, 40 lb BOD_5/d/acre and 15 lb TSS/d/acre appear reasonable (all rates based upon bed bottom area). Lower loading rates are likely appropriate for bed systems installed in fine textured soils. Substantially higher loading rates may be feasible for systems of shallow narrow trench design, for systems with better than septic tank pretreatment, or for systems with long-term resting provisions. Further investigation is warranted to quantify the relationship between applied wastewater quantity and composition, soil morphology and system geometry and that of long-term infiltration and purification capacities.
6. Soil absorption systems of shallow, narrow trench design should generally be used in preference to squarish beds.

Further field and laboratory investigation of restaurant systems are necessary to enhance the data base established by this investigation. Consideration and investigation of other commercial establishment systems would also be valuable.

Siegrist, R.L. 1987. Hydraulic Loading Rates for Soil Absorption Systems Based on Wastewater Quality, Proceedings of the Fifth National Symposium on Individual and Small Community Sewage Systems, December 1987. pp. 232 – 240.

This study reports on the importance of designing on-site sewage disposal systems based on both hydraulic loading and wastewater quality. It was noted that prior research had shown that soil clogging is generally accelerated under increasing hydraulic loading rates of a given wastewater effluent, or under increasing concentrations of organic matter and suspended solids at a given hydraulic loading rate. Within the research, the author concluded that concentrations of tBOD and TSS in restaurant septic tank effluent are more than 200% higher than those of domestic septic tank effluent which are nearly 200% higher than those of greywater septic tank effluent. The researcher states that the maximum hydraulic loading should be well below the soil's saturated hydraulic conductivity (only 3 to 5% of K_{sat}) in order to maintain low soil moisture contents and adequate soil aeration. The mass density loadings of tBOD and TSS appear to be key determinants of soil clogging development and system design should account for this fact. Requirements for lower hydraulic loading rates for lower quality effluents (e.g. restaurant septic tank effluent) would help mitigate harmful and costly performance malfunctions.

Siegrist, R, 2001, Advancing the Science and Engineering of Onsite Wastewater Systems, On-Site Wastewater Treatment Proceedings, Ninth National Symposium on Individual and Small Community Sewage Systems, March, 2001. 10 pages.

Onsite wastewater systems represent a necessary and appropriate component of the wastewater systems infrastructure in the U.S. In contrast to disposal oriented systems of the past, current and future systems are focused on advanced treatment that is protective of public health and environmental quality. System designs can now be assembled from an expanding array of options from which choices can be made regarding a given application. There is a considerable knowledge base regarding onsite system design, implementation, and performance that enables most commonly used systems to be effectively deployed in most settings. However, the current state-of-knowledge and standard-of-practice does have gaps and shortcomings that can preclude rational system design to predictably and reliably achieve specific performance goals. While choices today are often constrained by prescriptive regulatory codes, they also can be hampered by the absence of a sound science and engineering knowledge base. This paper discusses the basis and need for advancing the science and engineering of onsite wastewater systems to secure their necessary and appropriate status as a component of a sustainable wastewater infrastructure in the U.S.

Stuth, WL, 1989, Restaurant Waste Strength, June 1989. 19 pages.

Stuth, WL, Date Unknown, Treating High Strength Waste. 7 pages.

Annotation: This paper focused on the performance of grease traps and the performance of a NCS aerobic treatment unit.

Section 1 – The performance of grease traps
Six food service establishments were included in this study with FOG ranges of 152 mg/L to 14,958 mg/L.
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.

Section 1 – Conclusions
Commercial wastewater is not the same category as residential.
Grease traps level of FOG reduction is over-rated.
Undersized grease traps with inadequate detention capacity are of limited value in removing FOG.
A two or three day retention time along with filters does not reduce the FOG enough to prevent damage to the drainfield.
Treating and breaking down of FOG requires more oxygen than BOD requires for this treatment to occur.
Treating high strength wastewater the same as residential has led to disastrous results with serious financial complications for some establishments.

Section II – NCS Experience in Treating Systems Having High BOD and FOG.

This section discussed sampling of two food service establishments and how aerobic treatment can reduce high strength wastewater to residential levels.

Site 1 – Surge tank effluent
BOD_5 – average 1395 mg/L – high 3685 mg/L
TSS – average 535 mg/L – high 4375 mg/L
FOG – average 120 mg/L – high 200 mg/L

Site 2 – Grease trap effluent
BOD_5 – average 913 mg/L – high 1800 mg/L
TSS – average 185 mg/L – high 774 mg/L
FOG – average 207 mg/L – high 378 mg/L

Conclusion:
The treatment of commercial waste containing FOG, normally from a food service establishment, has three challenges: 1) having enough oxygen to treat or break down the FOG, 2) making sure the pH is high enough to assure that most microorganisms are able to survive, and 3) guarantee that there is an ongoing monitoring program in place. If one of three challenges is not met, the system is destined to fail

Stuth, WL, 1992, Keys to Understanding High Strength Waste in Residential and Commercial Applications, July, 1992. 26 pages.

Annotation: This paper addresses high strength wastewater in both residential and commercial settings giving examples and design considerations. Significant design considerations with commercial sites are the number of days and hours of operation, flows (average and peak), percent graywater vs. blackwater, BOD_5, grease and oils (G/O), temperature, pH, TSS, and DO. A typical commercial range in BOD_5 was given as 100 to 3000 mg/L. It was also noted that silty sand are particularly sensitive to BOD_5 overloading, however soil types 3 through 5 can handle a maximum BOD_5 of 230 mg/L. The lower the BOD_5 discharged into the drainfield, the longer the drainfield will function satisfactorily.
Examples of design considerations and the use of the Nibbler system were also addressed.

Stuth, WL, 1994, Monitoring High-Strength Waste Systems, NOWRA Proceedings, 1994. pp. 7 – 11.

Annotation: This article discusses monitoring of high strength systems to prevent failure. Monitoring provides early detection of problems that might result in the failure of a wastewater system. Early detection makes it possible to take remedial action before a system fails, thus minimizing the repair while protecting the environment.

Stuth, B, Garrison, C. 1997. Commercial Wastewater 101: On-Site Insight , National Onsite Wastewater Recycling Association (NOWRA), April-May 1997. pp. 3-4.

Annotation: The purpose of this article was to develop an understanding of the difference between high strength commercial wastewater and residential wastewater characteristics. An introduction was made into importance of determining organic loading of on-site sewage disposal systems prior to design and installation. An example equation was given in order to determine pounds of BOD_5 per day of both commercial and residential loading. Also noted was the lack of research data for Fats, Oils, and Greases. Identified influent parameters BOD_5 and FOG were:

Residential:
BOD_5 range = 110 mg/L – 250 mg/L
FOG range = 20 mg/L – 25 mg/L

Commercial:
BOD_5 range = >300 mg/L
FOG range = >25 mg/L

Research data at the time indicated that BOD_5 in excess of 300 mg/L and FOG in excess of 25 mg/L would shorten the life of drainfields mounds, sandfilter, and some aerobic treatment devices without pretreatment.

Stuth, W, Wecker, S, 1997, Grease and Oil Problems in the On-Site Industry, 9th NW On-Site Wastewater Treatment Short Course & Equipment Exhibition, September, 1997. pp. 341-348.

Stuth, W, 1999. Monitoring of Commercial Systems, NOWRA Proceedings 1999. pp. 93-97.

This report focuses on monitoring of commercial systems including the competency of the O & M company &/or staff, frequency of monitoring, timeliness of notification by O & M Manager, and timeliness of response by owner.

Tchobanoglous, G, Burton, F, 1991, Wastewater Engineering, Treatment, Disposal, Reuse, Third Edition, Metcalf & Eddy, Inc., p. 109.

Teague, J, Gross, M, 2001, Treatment of Milking Parlor and Milk House Wastewater Using a Recirculating Sand Filter, University of Arkansas, December 2001. 66 pages.

Turnberg, W, 1998, Antineoplastic and Other Hazardous Drug Waste Management, Environmental Management in Healthcare Facilities, WB Saunders Co., Phil. PA. 1998. pp. 79-89.

This report focuses on the hazardous characteristics of pharmaceuticals addressing the management and disposal of therapeutic agents that are referred to by ASHP and OSHA as hazardous drugs. This report is geared toward occupational risk for healthcare workers, solid waste disposal personnel, and municipal sewage treatment plant employees. Within the three categories of antineoplastic/hazardous drug waste is “Contaminated Human Excreta and Body Fluids - Urine, feces, vomitus, and blood of patients being treated with antineoplastic drugs have been found to contain high concentrations of either the antineoplastic agents or hazardous metabolites for up to 48 hours or more following treatment.” Personal protective equipment should be worn by personnel dealing with excreta, primarily urine, from patients who have received hazardous drugs in the last 48 hours.

U.S. EPA . 1980. Onsite Wastewater Treatment and Disposal Systems: Design Manual. EPA 625/1-80-012. U.S. EPA, Cincinnati, OH.

This document provides information on standard types of on-site wastewater treatment and disposal systems. The design information presented is intended as technical guidance reflective of sound, professional practice. The intended audience for the manual includes those involved in the design, construction, operation, maintenance, and regulation of on-site systems. Major topics considered include site evaluation procedures, wastewater characteristics and modification, on-site treatment and disposal methods, residuals disposal and management of on-site systems.

Washington State Department of Health, 2000, Recommended Standards and Guidance for Intermittent Sand Filter Systems, July, 2000.

Washington State Department of Health, 2000, Recommended Standards and Guidance for Recirculating Gravel Filter Systems, May, 2000.

Wong, M, Ngie-Hing, 1998, Total Suspended Solids and Oil & Grease Removal By A Grease-Trap Effluent Filter, NOWRA Proceedings, 1998. pp. 92-96.

This study was conducted in order to produce additional data on the application of a commercial grease-trap effluent filter (A300 produced by Zabel Environmental Technology). Previous research in Australia presented in the study showed 61-78% reductions in SS and 63-84% reductions in O&G. The objective of this project was to evaluate the effect of this effluent filter on the quality (SS and O&G) of the effluent discharged from the clear-zone of a restaurant grease-trap. The reductions for each restaurant need to be considered separately, due to the significan structural differences in the grease-traps and also the differences in the operation of the restaurants. Reductions in SS ranged from 27% to 57%, and the reductions in O&G from 44% to 52%. More studies need to be conducted.