

University Curriculum Development for Decentralized Wastewater Management

Wastewater Characterization

Text

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Wastewater Characterization

What do we need to know?

In order to design onsite wastewater treatment systems, we must consider the nature of the wastewater because the effluent quality depends upon the influent characteristics. The treatment capacity and treatment efficiency of systems are calculated based upon the influent concentrations and the effluent requirements.

$$\text{Efficiency} = [(C_{\text{in}} - C_{\text{out}})/C_{\text{in}}] 100$$

Where:

C_{in} = Influent concentration (typically mg/L)

C_{out} = Effluent concentration (typically mg/L)

And Efficiency is expressed as a percentage (%)

Also, the treatment capacity over time for biochemical processes is usually modeled as a first-order equation such that

$$C_t/C_0 = e^{-kt}$$

Where:

C_t = Concentration at time, t (typically in mg/L)

C_0 = Initial concentration at time = 0 (typically in mg/L)

k = reaction rate constant (typically in days⁻¹)

t = time (typically in days)

The concept of reaction rates is explained more fully in the section on *Fundamental Concepts for Environmental Processes* written by Dr. Ann Kenimer as part of this curriculum. For the purposes of explaining the importance of wastewater characteristics here, the ideas that the wastewater strength (concentration of contaminants), the availability of the contaminants as a food source, and the characteristic of being easily metabolized or being difficult to metabolize are all important factors to consider for designing the treatment processes. Treating all wastewater as if it is residential wastewater can have disastrous results.

The source of the wastewater influences the characteristics of the waste stream. In general, we can categorize the source as residential, municipal, commercial, industrial or agricultural. Tables documenting historically accepted values for wastewater characteristics are available for domestic wastewater. Untreated domestic wastewater has different characteristics from septic tank effluent. Septic tank effluent from a tank with an effluent screen (effluent filter) has different characteristics from unscreened effluent. Grinder pump effluent has different characteristics from any of the others. Wastewater from commercial sources such as restaurants, schools, supermarkets, hospitals, hotels, and convenience stores with food service, car washes, beauty salons, and other types of establishments can have characteristics specific to the wastewater-generating activities conducted as part of the business. A discussion of wastewater from sources other than domestic is included later in this section

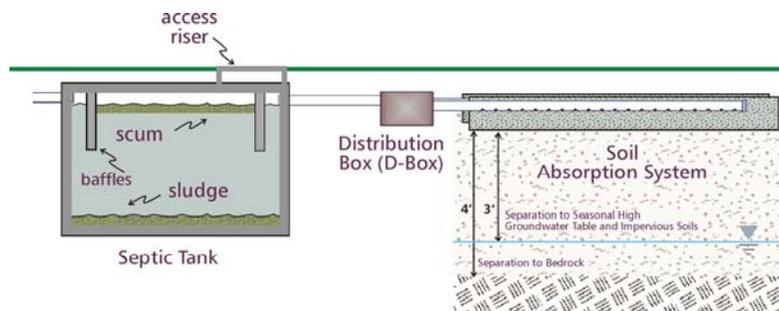
Typical components of raw sewage entering the septic tank and their concentrations are shown in Table 1. (1)

Table 1: Raw Sewage Characteristics

Component	Concentration Range	Typical Concentration
Total Suspended Solids, TSS	155 – 330 mg/L	250 mg/L
5-Day Biochemical Oxygen Demand, BOD ₅	155 – 286 mg/L	250 mg/L
pH	6 -9 s.u.	6.5 s.u.
Total Coliform Bacteria	10 ⁸ – 10 ¹⁰ CFU/100mL	10 ⁹ CFU/100mL
Fecal Coliform Bacteria	10 ⁶ – 10 ⁸ CFU/100mL	10 ⁷ CFU/100mL
Ammonium-Nitrogen, NH ₄ -N	4 - 13 mg/L	10 mg/L
Nitrate-Nitrogen, NO ₃ -N	Less than 1 mg/L	Less than 1 mg/L
Total Nitrogen	26 – 75 mg/L	60 mg/L
Total Phosphorus	6 - 12 mg/L	10 mg/L

(1) Source: U.S. EPA Onsite Wastewater Treatment Design Manual,
mg/L = milligrams per liter
s.u. = standard units
CFU/100 mL = Colony-Forming Units per 100 milliliters

One of the most common onsite wastewater treatment systems is the traditional septic tank followed by a soil absorption system. As the raw sewage flows through the treatment process, some contaminants are removed, and some contaminants are transformed. Figure 1 illustrates a traditional septic tank followed by a soil absorption system.



TRADITIONAL SEPTIC SYSTEM

STONE ENVIRONMENTAL INC

Figure 1: Traditional Septic Tank – Soil Absorption System

The Septic Tank

The septic tank, illustrated in figures 2 and 3, reduces the BOD₅ slightly without an effluent filter (screen). With an effluent screen, the BOD₅ reduction and the TSS reduction is enhanced. The septic tank processes convert the organic nitrogen compounds into ammonium; however no conversion of ammonium to nitrate is expected to occur in the septic tank. The septic tank alone is not expected to affect the phosphorus concentrations in the wastewater. Some coliform bacteria removal and reduction occurs in the septic tank. The septic tank and its treatment processes are considered in detail in the section *Septic Tanks* written by Professor Robert Seabloom as part of this curriculum.



Figure 2: Septic Tank (Residential)

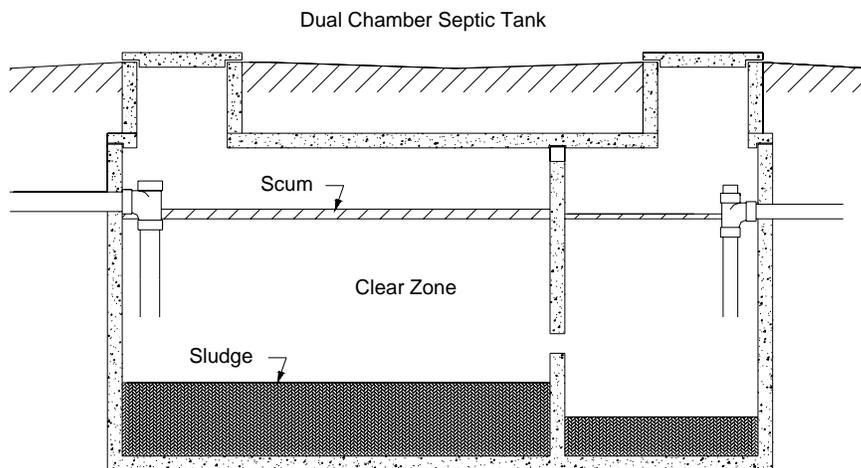


Figure 3: Septic Tank Profile

The typical concentration of the wastewater components in septic tank effluent are shown in Table 2. A comparison of Tables 1 and 2 show the expected reductions of contaminants in a septic tank.

Table 2: Septic Tank Effluent Characteristics

Component	Concentration Range	Typical Concentration
Total Suspended Solids, TSS	36 - 85 mg/L	60 mg/L
5-Day Biochemical Oxygen Demand, BOD ₅	118 - 189 mg/L	120 mg/L
pH	6.4 – 7.8 s.u.	6.5 s.u.
Fecal Coliform Bacteria	10 ⁶ – 10 ⁷ CFU/100mL	10 ⁶ CFU/100mL
Ammonium-Nitrogen, NH ₄ -N	30 – 50 mg/L	40 mg/L
Nitrate-Nitrogen, NO ₃ -N	0 – 10 mg/L	0 mg/L
Total Nitrogen	29.5 – 63.4 mg/L	60 mg/L
Total Phosphorus	8.1 – 8.2 mg/L	8.1 mg/L

(2) Sources: EPA Onsite Wastewater Treatment System Manual, 2002, EPA/625/R-00/08 and Crites and Tchobanoglous, *Small and Decentralized Wastewater Management Systems*, McGraw-Hill, 1998

The leaching system

The leaching system – sometimes called the soil absorption system or dispersal system – also performs physical and biochemical treatment. The physical processes include straining and filtration and detention or retardation of the wastewater in the soil. Designing the various hydraulic components and options for the soil absorption system is discussed in detail in the *Hydraulics* and the *Effluent Conveyance* sections written by Dr. Paul Trotta as part of this curriculum.

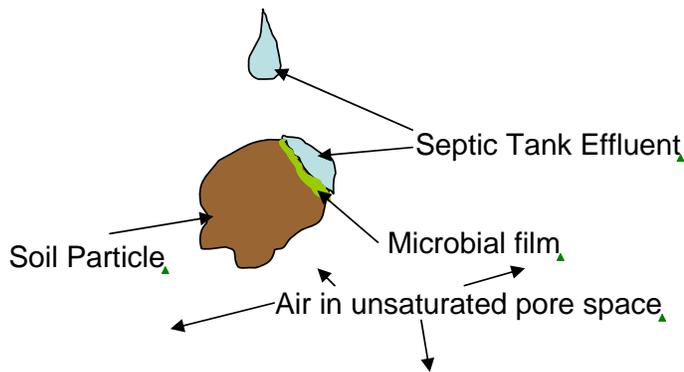
The soil particles provide surfaces on which biochemical processes occur. As the effluent moves through the soil infiltrative surface, microbial growth is stimulated and a biomat forms. As the wastewater moves through the biomat and into and through the soil, organic compounds are used as a source of food by the microbes and converted to carbon dioxide and water.





Figure 4: Perforated Pipes (covered by a geotextile fabric) in a Traditional Soil Absorption Bed (Note the gravel seen between the pipes.)

As shown in this equation, oxygen is required for the reaction to proceed to carbon dioxide and water. In well-sited and properly-functioning septic systems, this process occurs within the boundaries of the site upon which the system is located, and the wastewater is renovated within a distance that prevents contamination of groundwater or surface water. This should be well-illustrated and explained in the *Soil and Site* module in the Practitioners' Curriculum developed by North Carolina State University.



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Figure 5: Soil, Wastewater, and Microbial Film

Ammonium in the wastewater is converted to nitrite and then to nitrate by processes using free oxygen (aerobic processes) called nitrification. First, ammonium is converted

to Nitrite plus hydrogen ions (Equation 2). Then, nitrite is converted to nitrate and hydrogen ions (Equation 3). (For more information on nitrogen processes, see the *Onsite Nitrogen Removal* chapter by Stew Oakley.)



As with microbial degradation of organic matter, the nitrification reaction requires the presence free oxygen. Thus, the soil must be unsaturated to allow the wastewater to move through the soil under unsaturated conditions. For more information on this, see the *Water Movement and Soil Treatment* Module by Gustafson and Anderson (part of the Practitioner's Curriculum.)

If the nitrified wastewater encounters anoxic conditions and contains enough organic compounds, the nitrate can be converted to nitrogen gas and other gases by anaerobic processes called denitrification as shown in Equation 4.



These processes are affected by the concentration of the wastewater applied to the soil. If typical septic tank effluent is applied, the development of the biomat will be different from its development when advanced secondary quality effluent is applied, or if high-strength wastewater is applied.

Typical values of contaminant concentrations at 0.6 meters and 1.2 meters (2 feet and 4 feet) from the soil absorption trench are shown in the following table taken from the 2000 EPA Onsite Wastewater Treatment Manual.

Table 3: Case Study: Septic Tank Effluent and Soil Water Quality

Parameter (units)	Statistics	Septic Tank Effluent Quality	Soil Water Quality ^b at 0.6 m	Soil Water Quality ^b at 1.2 m
BOD (mg/L)	Mean	93.5	<1	<1
	Range	46 -156	<1	<1
	#samples	11	6	6
TOC (mg/L)	Mean	47.4	7.8	8.0
	Range	31 – 68	3.7 – 17.0	3.1 – 25.0
	#samples	11	34	33
TKN (mg/L)	Mean	44.2	0.77	0.77
	Range	19 – 53	0.4 – 1.40	0.25 – 2.10
	#samples	11	35	
NO ₃ -N (mg/L)	Mean	0.04	21.6	13.0
	Range	0.01 – 0.16	1.7 – 39.0	2.0 – 29.0
	#samples	11	35	32
TP (mg/L)	Mean	8.6	0.40	0.18
	Range	7.2 – 17.0	0.01 – 3.8	0.02 – 1.80
	#samples	11	35	33
TDS (mg/L)	Mean	497	448	355
	Range	354 – 610	184 – 620	200 – 592
	#samples	11	34	32
Cl (mg/L)	Mean	70	41	29
	Range	37 – 110	9 – 65	9 – 49
	#samples	11	34	31
F. Coli (log # per 100 mL)	Mean	4.57	nd ^c	nd
	Range	3.6 – 5.5	<1	<1
	#samples	11	24	21
F. strep. (log # per 100 mL)	Mean	3.60	nd	nd
	Range	1.9 – 5.3	<1	<1
	#samples	11	23	20

^aThe soil matrix consisted of a fine sand; the wastewater loading rate was 3.1 cm per day over 9 months. TOC = Total organic carbon; TKN = Total Kjeldahl nitrogen; TDS = Total dissolved solids; Cl = Chlorides; F. Coli = Fecal Coliform; F. strep = Fecal Streptococci

^bSoil water quality measured in pan lysimeters at unsaturated soil depths of 2 feet (0.6 meters) and 4 feet (1.2 meters)

^cnd = none detected

Source: Adapted from Anderson, 1994

Note: Table reproduced from EPA Onsite Wastewater Treatment System Manual, EPA/625/R-00/08.

Wastewater from Sources Other than Residential

Some examples of facilities that produce wastewater that is dissimilar to residential (domestic) wastewater include the examples shown in Table 4 below.

Table 4: Non-residential wastewater concerns

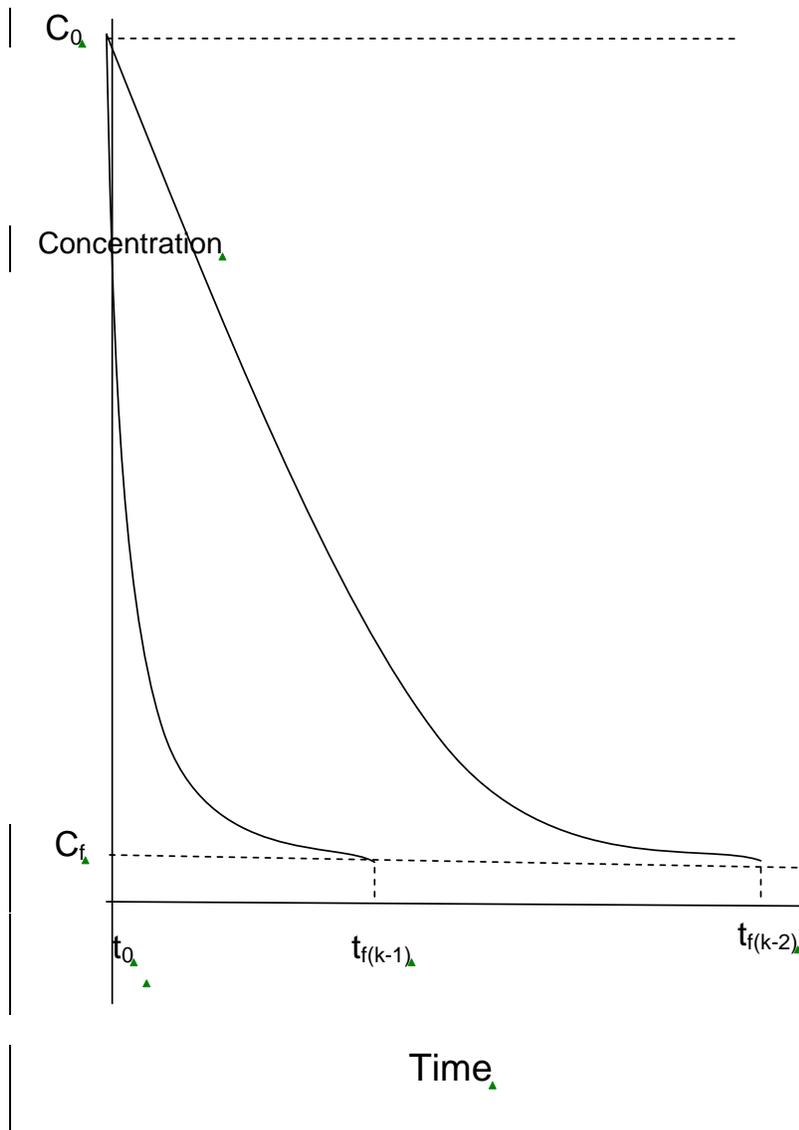
<u>Restaurants and convenience stores, where cooking occurs</u>	This includes service stations and truck stops. Cooking oils, animal fats, detergents, cleansers, and other materials are all important components of waste streams from these facilities
<u>Dairy bars</u>	Milk products
<u>Hospitals and clinics</u>	Antibiotics, antibacterial soaps and cleansers and pharmaceuticals may become part of the wastewater stream.
<u>Meat processing and slaughterhouses</u>	Blood, hair, cleaning agents (possibly acidic or caustic or both), fats, oil and grease.
<u>Car Washes</u>	Soap, grit, particulates, "road tar," petroleum wastes.
<u>Photography laboratories</u>	Photographic chemicals
<u>Beauty salon</u>	Hair treatment chemicals and dyes, soap and shampoo
<u>Laundries and dry cleaners</u>	lint, particulate, dry cleaning agents, acidic and caustic compounds, soaps, dyes
<u>Schools</u>	cafeterias that can discharge wastewater that resembles restaurant waste; chemistry and biology laboratories that can discharge chemical wastes or biological wastes photography and journalism laboratories that can discharge photo processing chemicals; home economics laboratories where clothes washing, cooking, or other activities may generate wastewater similar to a restaurant or a laundry. Also, see the note above regarding TSP from "chemical dishwashers."
<u>Mortuaries</u>	located in rural areas served by decentralized wastewater systems may have even more particular considerations in terms of biological agents, embalming fluids, soaps, and cleansers that become part of the wastewater stream.

An additional issue is that some dishwashers now use trisodium phosphate (TSP) as a chemical cleaning agent. This allows the dishwasher temperature to be set lower to save energy. However, there is some anecdotal field evidence indicating that TSP emulsifies the grease into smaller particles that are not removed in grease traps or septic tanks.

As illustrated by these examples, wastewater may consist of any number of components that can influence its “treatability.” When considering the treatment process as a first-order reaction, an easily biodegradable component such as blood may have a very large reaction rate constant, k . A less readily degradable component such as grease may have a very small reaction rate constant. A large rate constant means that if the waste is aerobically biodegraded, the oxygen uptake rate is very rapid and oxygen must be supplied at a high rate. This affects the selection of the aeration method – whether it can be passive aeration or if mechanical aerators must be chosen, and if so, the rate that they must supply the air. The aeration rate affects the aerator size, horsepower, and physical delivery system such as compressors or blowers, diffusers, pipes tubes, induced draft aerators, etc. Although the aeration rate must be high for an easily degradable waste, the reaction, or detention, time (and therefore the tank size) may be smaller than for a less readily degradable waste, i.e. small reaction rate constant.

For the less easily biodegradable waste (the very difficult wastes are sometimes called “recalcitrant”), the air may not need to be supplied as quickly, however the reaction time would be longer. This translates to a higher tank volume – larger tanks – so the wastewater can react for a longer time in order for the reaction to proceed to the same level of completion as the quickly degrading waste.

Another factor that influences the reaction rate is temperature. As mentioned in *Fundamental Concepts for Environmental Processes* written by Dr. Ann Kenimer, a rule of thumb is that the reaction rate doubles for every 10^0 C temperature increase. This means that oxygen uptake is more rapid at warmer temperatures, requiring air to be supplied at a higher rate. The waste degrades more quickly at warmer temperatures, so it need not be held in the treatment system as long when it is warm. The converse is also true: in the winter, oxygen uptake is low and air need not be supplied as fast. However, the waste takes longer to degrade, and would thus need to stay in the treatment system longer during cold months. The practical implication of this is that aerators are designed using summer temperatures and detention tanks are designed using winter temperatures. An illustration of the way that reaction rates affect the final concentration is shown in Figure 6.



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Figure 6: Reaction Rate and Time for Completion of Treatment

Figure 7 shows the affect of the reaction rate upon the oxygen requirement (Biochemical Oxygen Demand). In this illustration, k_1 is the fast reaction rate caused either by warm temperatures or by a very easily degradable wastewater, and k_2 is the slower reaction rate caused by cold temperatures or by a more difficult to degrade wastewater. In both cases,

the final concentration at the end of the treatment is the same. It simply takes longer for the waste with k_2 to reach the final concentration.

Figure 7 illustrates the same two wastewaters and reaction rates, showing the rate at which the oxygen demand is exerted. The implication of this figure is that with a faster oxygen demand i.e., a faster reaction rate, the oxygen must be supplied at a faster rate, but for a short time. With the slower reaction rate, k_2 , the oxygen can be supplied more slowly, but for a longer time. In both figures 6 and 7, if the volume of wastewater processed is the same, the same amount is degraded, and the same amount of oxygen is supplied. The waste is simply degraded over a longer period of time (longer detention time) and the oxygen is supplied for a longer time and at a slower rate (pounds per hour) for k_2 .

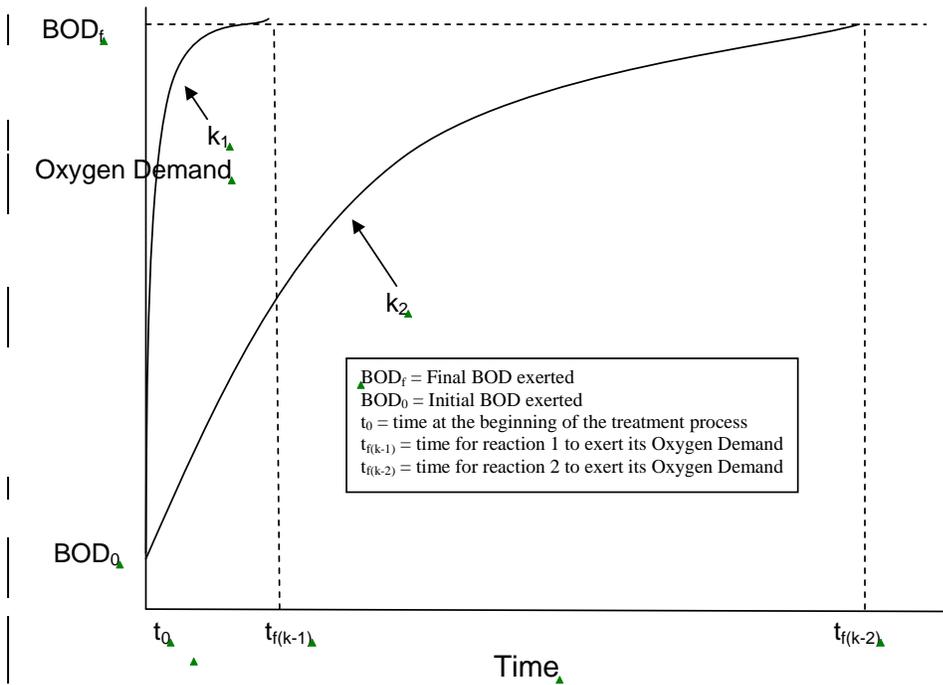


Figure 7: Reaction Rate and Oxygen Demand

An example of this is diluted blood with a BOD of approximately 150 mg/L. The blood has a BOD similar to residential strength wastewater, but it is very easy for the microbes to degrade, and therefore, the reaction rate is very fast. It is possible that a treatment

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system that performs perfectly well, producing a high quality effluent with little odor or clogging when treating residential wastewater, would simply be overwhelmed and could become anaerobic and clogged if the diluted blood is processed. Even if the same flow rate passes through the treatment process, and the wastewater strength is the same, the treatment unit may not be designed to provide oxygen at a rate high enough to prevent the wastewater treatment process from becoming anaerobic. The result could be odors, incomplete treatment, and clogging of the treatment unit.

A Word about Grease

Another important wastewater characteristic, although not typically listed in tables of typical properties of wastewater, is temperature. The previous discussion illustrates the importance of temperature on the biochemical reactions for wastewater treatment, however, temperature may also have a significant effect on the physical treatment processes. One common example of this is a restaurant or school cafeteria wastewater. Wastewater from cooking and dishwashing may have high concentrations of fats, oil, and grease (FOG). Typically, the method for removing grease from kitchen waste is to plumb the kitchen drains through a grease trap. Grease traps are simply sedimentation basins that allow the wastewater to slow down long enough to let the grease float to the top. The grease trap outlet is baffled to allow liquid to pass under the floating grease and flow onto the wastewater treatment system.

In order for fats, oil and grease to float (to state the obvious) it must be lighter than water. Congealed FOG tends to be lighter than water, and the grease needs to cool to congeal and separate from the water carrying the grease away from the kitchen. Some of the considerations for allowing the FOG to separate and float include the temperature of the water entering the grease trap, the temperature of the grease trap, and the length of time the wastewater is allowed to stay in the grease trap (detention time) to cool before passing onto the next wastewater collection or treatment process. A longer detention time allows the contents of the grease trap to cool, and the FOG to separate.

One of the ways to clean dishes more effectively is to increase the temperature of the water entering the dishwasher. Also, public health officials inspect kitchens, and check the temperature of the dishwasher and the time that the dishes are exposed to the hot water, so in order to be safe, some restaurants run the dishwashers at very high temperatures. The result may be that the wastewater entering the grease trap is too hot, and the FOG doesn't have adequate detention time in the grease trap to cool and separate. The FOG may be carried onto the next treatment process, and either clog or overwhelm a secondary treatment system, or clog the soil absorption system. Setting the dishwasher temperature to a lower setting may allow the grease trap to operate more effectively.

Another consideration for grease trap effectiveness is that grease trap sizing criteria in prescriptive regulations are typically from old regulations written when animal fat was the main form of cooking oil used in kitchens. Modern oils include liquid oils that

remain liquid at room temperature, and may be more difficult to separate from the wastewater than animal fats (lard and suet). Again, temperature, time, and the emulsion properties of the FOG in the wastewater affect the grease trap performance, and may cause poor performance or failure of a downstream treatment process. Also, dishwashing detergents may have the effect of keeping the FOG suspended or emulsified in the waste stream, allowing the FOG to pass through the grease trap with the water.

Pumping the grease trap is a cost to the business that some restaurant managers or school maintenance personnel may want to decrease or eliminate. Products are available that will keep the grease in suspension, allowing the grease to pass through the grease trap, and giving the illusion that the grease has “gone away.” The grease may well be passing through the grease trap rather than being “trapped.” Although this is one method to cut costs in the short term by reducing or eliminating the cost to pump the grease trap (and thereby improving the manager’s profit and loss sheet), the long term cost may well be repair or replacement of expensive downstream wastewater treatment equipment or the soil absorption system. The wastewater characteristics may be modified by adding seemingly helpful agents that result in poor performance and possibly damage to the wastewater treatment processes.

Determining Wastewater Characteristics

Since not all wastewater is residential wastewater, some effort may need to be exerted to determine the wastewater characteristics. Tables 1 and 2 are reasonable and reliable methods for estimating residential wastewater strength. For wastewater generated by establishments other than homes, some extra effort may be needed to determine the wastewater characteristics.

If the wastewater is already being generated, and a new process or a modification is being designed, the waste stream can be sampled and analyses can be performed to determine the wastewater characteristics. When sampling to determine the wastewater characteristics, some understanding of the wastewater generating processes and patterns is helpful to design the sampling program. For example, if the wastewater is from a school, it may be helpful to sample during the time that lunches are being prepared and served and also during the time that the dishes and the kitchen are being cleaned. In addition, it may be helpful to sample during recess at elementary schools. Possibly, a 24-hour composite sample would be helpful if the process has the potential for being designed with tankage for large detention time, allowing for mixing of the waste. If the waste is processed in batches as it is generated, the fluctuations in wastewater characteristics may be very important, and sampling in discrete increments may be the most effective way to gather information for design. Automatic sampling equipment eases the task of sampling in timed increments as well as collecting a 24-hour composite. Samplers are available that can provide refrigeration while the sample is being collected and stored inside the sampler.

If the wastewater generating facility is not already in place, and estimates must be made for future wastewater treatment, similar installations – schools, convenience stores, truck stops, restaurants, etc. may be sampled and analyzed to provide a comparison for estimating wastewater characteristics.

Once the wastewater samples have been properly collected, simple analyses for BOD, Total Suspended Solids, pH, acidity or alkalinity, coliform, nitrogen, and other nutrients may or may not be adequate for characterizing the waste. Some wastewater may contain compounds that are very difficult to treat or that are toxic to the microbes typically populating wastewater treatment systems. Some laboratories have the capability to perform treatability studies. Essentially, the wastewater is processed in bench scale treatment systems, and the rate of oxygen demand is measured. This is a simplification of the treatability study, but the goal is typically to determine the rate constant, sludge production rate, oxygen uptake rate, and other parameters for designing the treatment process. An examination of the wastewater under a microscope is also a common way to see if the microscopic life exists in the wastewater. If no life is observed, there is a concern that a toxin is present in the wastewater.

The Concept of Load

Most of the discussion so far, along with the tables and graphs presented, has focused upon the concentration of the constituents in the wastewater. The concentration tables may be quite familiar. Another set of tables is available to the designer, and these tables show typical flow rates from various establishments. Table 4, from the US EPA 2002 *Onsite Wastewater Treatment Systems Manual* provides information on typical residential wastewater flows. Most states have tables within their onsite wastewater regulations that prescribe flows to be used for design. For larger flows, such as from multiple dwellings, community systems, and subdivisions the regulatory agencies generally have an estimated flow per dwelling or equivalent dwelling unit (EDU) that is used for design. Information regarding flow rates from sources other than residences is shown in Table 5, taken from the US EPA 2002 *Onsite Wastewater Treatment Systems Manual*.

Table 4: Residential Wastewater Flows

Study	Number of Residences	Study Duration (months)	Study Average (gal/person/day)	Study range (gal/person/day)
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Brown & Caldwell (1984)	210		66.2 (250.6) ^a	57.3 – 73.0 (216.9 – 276.3) ^b
Anderson & Siegrist (1989)	90	3	70.8 (268.0)	65.9 – 75.6 (249.4 – 289.9)
Anderson, et al. (1983)	25	2	50.7 (191.9)	26.1 – 85.2 (98.9 – 322.5)
Mayer et al. (1999)	1188	1 ^c	69.3 (252.3)	57.1 – 83.5 (216.1 – 316.1)
Weighted Average	153		68.6 (259.7)	

^aBased on indoor water use monitoring and not wastewater flow monitoring

^bLiters per person per day in parentheses

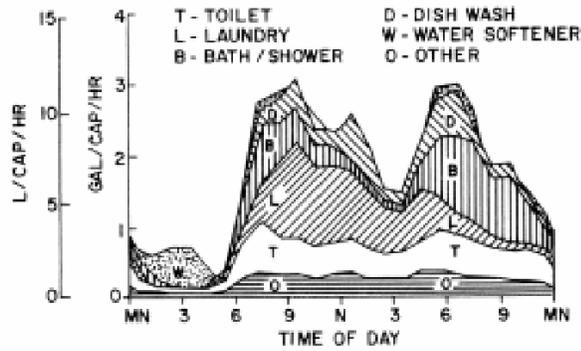
^cBased on two weeks of continuous monitoring in each of two seasons at each home

From US EPA *Onsite Wastewater Treatment Systems Manual*, EPA/625/R-00/008, US EPA Office of Water, 2002

Tables 4 and 5 show the flow rates from particular types of establishments, and using these tables will provide an estimate of the volume of wastewater to be treated each day. The treatment processes may be sized for a particular daily volume as well as maximum “instantaneous” flow that can be processed through the system. Figure 8 taken from the US EPA 2002 *Onsite Wastewater Treatment Systems Manual* shows the typical variation in the wastewater flow from a single family residence.

In addition to the daily flow variation, seasonal variations may also occur. Typically, wastewater treatment processes are sized to treat the maximum daily flow rather than simply having the capacity to treat the average daily flow. The maximum daily flow is the maximum flow that occurs over the course of a single day, perhaps 450 gallons per day for a typical 3-bedroom home. The average daily flow is the average of the flows that occur during single days over the course of some period of time – perhaps years. This may be 160 gallons per day.

Philosophically (if not particularly statistically rigorous) designing the wastewater treatment system performance based upon average daily flow would imply that 50 percent of the time, the system is in compliance, and 50 percent of the time the system is out of compliance. For this reason, treatment systems are typically designed to produce the required effluent quality when treating the maximum daily flow. This concept is the hydraulic loading rate. In sizing for the hydraulic loading rate, the volume of water



Source: University of Wisconsin, 1978.

Figure 8: Daily Indoor Water Use Patterns for Single-Family Residences

flowing through the treatment process is the design parameter under consideration. For the concept of mass loading rate, the idea of the mass or weight of a particular contaminant flowing through the system over some time is considered. The “organic loading rate,” the number of pounds or kilograms of BOD per day, or the “solids loading rate,” the number of pounds or kilograms of TSS per day are common mass loading rates.

By using the wastewater characteristics determined by estimates from tables or typical residential wastewater, or perhaps by sampling and analyzing a particular wastewater stream, and combining this with the flow rate, the wastewater “load” may be calculated. The calculation is the product of the flow rate and the concentration as follows:

$$\text{Load} = \text{Concentration} \times \text{Flow}$$

Typically, as shown in the tables provided in this document, the concentration is given in units of mg/L and the flow rate is given in units of gallons per day. Conversion to consistent units is required to produce units of mg/day or lbs/day or other expressions of weight (or mass) of contaminant per time. A complete discussion of units and conversions is provided in the section *Fundamental Concepts for Environmental Processes* written by Dr. Ann Kenimer as part of this curriculum.

Table 5: Typical Wastewater Flows from Various Facilities

Facility	Unit	Flow gallons/unit/day		Flow Liters/unit/day	
		Range	Typical	Range	Typical
Airport	Passenger	2-4	3	8-15	11
Apartment House	Person	40-80	50	150-300	190
Automobile Service Station	Vehicle Served	8-15	12	30-57	45
	Employee	9-15	13	34-57	49
Bar	Customer	1-5	3	4-19	11
	Employee	10-16	13	38-61	49
Boarding House	Person	25-60	40	95-230	150
Department Store	Toilet Room	400-600	500	1500-2300	1900
	Employee	8-15	10	30-57	38
Hotel	Guest	40-60	50	150-230	190
	Employee	8-13	10	30-49	38
Industrial Building (sanitary waste only)	Employee	7-16	13	26-61	49
Laundry (self service)	Machine	450-650	550	1700-2500	2100
	Wash	45-55	50	170-210	190
Office	Employee	7-16	13	26-61	49
Public Lavatory	User	3-6	5	11-23	19
Restaurant (with toilet)	Meal	2-4	3	8-15	11
Conventional	Customer	8-10	9	30-38	34
Short Order	Customer	3-8	6	11-30	23
Bar/Cocktail Lounge	Customer	2-4	3	8-15	11
Shopping Center	Employee	7-13	10	26-49	38
	Parking Space	1-3	2	4-11	8
Theater	Seat	2-4	3	8-15	11

(3)From US EPA *Onsite Wastewater Treatment Systems Manual*, EPA/625/R-00/008, US EPA Office of Water, 2002

Conclusions

- Influent wastewater concentrations and flows (load) affect effluent water quality

- Wastewater characteristics depend upon the activity of the generating establishment

- Raw sewage characteristics are different from septic tank effluent and from treated (soil absorption, aerobic treatment units, media filters, etc.) effluent.