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SMALL SCALE WASTE MANAGEMENT PROJECT

Commercial Wastewater On-site Treatment and Disposal

by

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COMMERCIAL WASTEWATER ON-SITE TREATMENT AND DISPOSAL

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Member ASAE

In unsewered areas, private facilities must be utilized for treatment and disposal of wastewaters not only from households, but also from a myriad of commercial establishments including restaurants, taverns, and motels. The design practice of commercial systems has normally been substantially the same as that utilized for household systems. As a result, design and operation of commercial systems generally has not accounted for wastewater flow variations, organic loading, or other factors commonly considered in engineering of non-soil absorption wastewater facilities. The suitability of these casual design and operation practices has been questioned recently in light of a growing poor performance record for on-site wastewater systems serving some commercial establishments.

As part of the Small Scale Waste Management Project, an investigation was undertaken into the design and performance of septic tank soil absorption systems for commercial wastewaters. Of particular interest were restaurant facilities, as on-site systems serving several of these had exhibited exceptionally poor performance. The objectives of the study were to characterize commercial septic tank effluents, determine the design and operational characteristics of commercial soil absorption systems, and develop modifications as appropriate to household system design and operation practices to enhance commercial system performance. The methods and results of this investigation are summarized herein, while details regarding the work may be found elsewhere (Siegrist et al. 1984).

FIELD INVESTIGATION

Forty-two establishments located throughout Wisconsin were initially visited and inspections were made to assess, in general, the operational status of the on-site wastewater systems. From this pool of systems, twelve were selected for detailed study based upon several criteria, including adequate as-built data, design per generally accepted practice, and owner's willingness to participate. To minimize the number of independent variables, only systems located in soils of sand texture were selected. Field investigations at the twelve establishments occurred between March and September 1983.

Materials and Methods

Establishment Characteristics: The establishments studied included six restaurants, two large motel/lounge complexes, three country (golf) clubs,

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and one bar and grill (Table 1). The on-site wastewater facilities were designed for daily wastewater flows of 7 to 95 m^3/d and included one or more septic tanks for pretreatment of the raw wastewater (Table 2). Many also had a grease interceptor through which certain kitchen waste streams passed prior to entry to the septic tanks. All except System No. 5 employed a pump to deliver septic tank effluent (STE) to the soil absorption system. In Systems 1-5 a distribution box was used to distribute the STE and in Systems 6-12 a pressure network was used to distribute the STE. Ten of the systems were of bed geometry, ranging in size from 149 m^2 to 1951 m^2. Eleven systems were installed in soils of sand texture with reported percolation rates of less than 3.9 min/cm (Table 3). System No. 5 was located in less permeable soils, with a reported percolation rate of 8 to 11 min/cm.

Table 1. Characteristics of the Commercial Establishments Studied.[a]

Site No.	Type	Restaurant Service[b]	Restaurant Seats	Bar Seats	Motel Units	Employees	Other
1	Supper Club	D	70	22	0	5	-
2	Supper Club	D	68	32	0	12	3 Apt.(5 BR)
3	Supper Club	L,D,S	125	62	0	13	-
4	Motel/Restaurant/Bar	B,L,D,S	160	150	120	70	Banquets,Pool
5	Supper Club	D,S	210	22	0	30	Dances
6	Motel/Restaurant/Bar	B,L,D,S	240	100	100	40	500 Banquet Seating, Pool,Showers
7	Supper Club	D	80	30	0	10	-
8	Country Club	L,D,S,	70	96	0	16	Locker Room, Showers
9	Supper Club	B,L,D,S	160	35	0	6	300 Banquet Seating,Dances
10	Country Club	L,D,S	108	65	0	12	Locker Room, Showers
11	Country Club	L,D,S	100	20	0	9	Locker Room, Showers
12	Bar/Grill	L,D	40	34	0	4	2 BR Home

[a]Refer to Tables 2 and 3 for the characteristics of the wastewater facilities.
[b]Full course meals were served at all sites except Site 12 which served only sandwiches. B = Breakfast, L = Lunch, D = Dinner, S = Special Events (Meetings, Parties,...).

Monitoring Procedures: Wastewater flow was determined at nine sites utilizing monthly water meter readings. The frequency and volume of wastewater applications to the soil absorption system at each of six sites were monitored with pump event counters. The STE composition at each facility was characterized using grab samples collected from the pump chamber or outlet of the last septic tank. These samples were analyzed according to Standard Methods (1980). The performance of each soil absorption system was assessed monthly. At each site, the pump chamber was visually inspected, as was the land surface over and around the absorption area. Observation vents which extended through the gravel bed to the infiltrative surface were inspected and the magnitude of any STE ponding was noted. The owner or operator of each establishment was also consulted regarding system operation and maintenance since the last site visit.

Table 2. Wastewater Pretreatment Facilities.[a]

Site No.	Design Flow (m^3/d)	Grease Trap (m^3)	Septic Tanks[b] (m^3) 1st	2nd	3rd	4th	Pump Chamber (m^3)	Install. Date
1	13	None	7.2	3.8	2.2	-	1.1	1980
2	17	None	4.9	3.8	3.8	3.8	3.8	1979
3	19	Inhouse	25.6	-	-	-	25.6	1982
4	-	Yes	54.2	97.5	-	-	-[c]	1975
5	-	Inhouse	3.8	5.9	5.9	-	-	1974
6	95	3.8	75.7[d]	75.7[d]	189[d]	-	22.7	1980
7	12	3.8	9.5	9.5	-	-	3.8	1983
8	17	None	17.0	-	-	-	4.5	1980
9	12	3.0	3.8	3.8	3.8	3.8	17.4	1981
10	20	Inhouse	15.1	5.7	-	-	9.5	1981
11	15	1.9	1.9[e]	1.9[e]	7.6[e]	7.6[e]	3.8	1979
12	7	None	5.7	4.7	-	-	9.5	1981

[a]Based upon data from as-built plans and field inspection. Refer to Tables 1 and 3 for additional facility characteristics.
Note: 1 m^3 = 264 gal.

[b]Septic tanks installed in series as shown unless otherwise noted.

[c]Septic tank 2 plus pump chamber = 97.5 m^3. Pump chamber size unknown.

[d]Two 75.7 m^3 septic tanks in parallel serving restaurant/bar. 189 m^3 septic tank serving motel.

[e]Two 1.9 m^3 septic tanks in series serve locker rooms; two 7.6 m^3 septic tanks receive effluent from the two 1.9 m^3 tanks plus kitchen wastewater from grease trap.

Table 3. Soil Absorption System Characteristics.[a]

Site No.	Design Flow (m^3/d)	Site: Slope (%)	Soil Texture	Perc. (min/cm)	GW[b] (m)	System: Type[c]	No.	W (m)	L (m)	D (m)	Area[d] (m^2)
1	13	0-1	lfs	-	1.8	IGGT	13	1.5	30.5	0.8	604
2	17	4-6	sl	1.4	2.0	IGGB	1	19.8	44.2	0.9	876
3	19	1	ls	3.2	1.5	IGGB	1	30.5	47.5	0.8	1449
4	-	0-1	ls	<3.9	-	IGGB	1	23.2	82.3	-	1905
5	-	-	-	9.9	-	IGGB	1	-	-	-	1254
6	95	0-1	ls	<0.4	>1.9	IGPB	2	30.5	32.0	-	1951
7	12	0-1	sl	3.5	>1.8	IGPB	1	14.6	17.1	0.8	249
8	17	2-5	s	-	>1.9	IGPB	1	10.7	30.5	0.7	325
9	12	0-1	s	<0.8	>1.8	IGPB	1	11.0	30.5	0.9	334
10	20	5	ls	0.8	-	IGPT	7	1.5	36.6	0.7[e]	390
11	15	0-1	s	1.8	>2.4	IGPT	1	12.8	25.0	0.6	279
12	7	1-2	s	-	0.9	MB	1	4.9	30.5	MB[c]	149

[a]Based upon data from soil test reports and as-built plans. Refer to Table 1 and 2 for additional facility characteristics.
Note: 1 m^3 = 264 gal.; 1 m = 3.28 ft.; 1 min/cm = 2.54 min/in.

[b]Depth below ground surface to groundwater.

[c]IGGT = Inground gravity trench (conventional), IGGB = Inground gravity bed (conventional), IGPB = Inground pressure bed, MB = Mound with bed, IGPT = Inground pressure trench.

[d]Total horizontal soil infiltrative surface area.

[e]Depth below final ground surface after adding 0.2 m cover over system.

Results

Septic Tank Effluent Characteristics: The average daily wastewater flows at nine establishments were all substantially less than the design flow (Table 4). These results confirmed the conservative nature of design flows as predicted according to current practice (Wisc. Adm. Code, 1980; Siegrist et al., 1976; Otis, 1978; Harkin et al., 1979).

The compositions of the STE's at each establishment are delineated in Table 4. While not tabulated, analyses for total and fecal coliforms in the samples of STE from each of eight establishments revealed concentrations of 1.8×10^6 to 1.1×10^9 and 6.5×10^5 to 2.3×10^7 org./100 ml, respectively. The measured STE compositions varied widely between the different establishments. However, temporal variations at a given site were relatively small as evidenced by coefficients of variation which were typically less than 0.40.

Table 4. Average Concentrations of Selected Constituents in Commercial Septic Tank Effluents.[a]

Type[b]	Site No.	Flow (m^3/d)	Composition							
			BOD_5 (mg/L)	COD (mg/L)	TKN (mg-N/L)	TP (mgP/L)	TSS (mg/L)	Oil/ Grease (mg/L)	Temp. (°C)	pH
Restaurant	1	2.0(16)[c]	582	1196	82	24	187	101	8-22	5.6-6.4
	2	-	245	622	64	14	65	40	8-22	6.6-7.0
	3	6.2(33)[c]	880	1667	71	23	372	144	13-23	5.8-6.3
	5	-	377	772	30	15	247	101	16-21	5.7-6.8
	7	2.9(25)[c]	693	1321	78	28	125	65	4-26	5.5-6.9
	9	5.9(49)[c]	261	586	73	19	66	47	7-25	5.8-7.0
Motel Complex	4	53.4(-)	171	381	34	20	66	45	20-28	6.5-7.1
Country (Golf) Club	8	-	197	416	36	13	56	24	6-20	6.5-6.8
	10	14.2(71)	333	620	63	17	121	46	13-26	6.2-6.8
	11	3.2(21)	101	227	36	10	44	33	10-23	6.2-7.4
Bar/ Grill	12	1.7(24)	179	449	61	7	79	49	8-22	6.0-7.0
Ave.[d]	-		365	751	57	17	130	63	-	-
Min.[d]	-		101	227	30	7	44	24	4	5.5
Max.[d]	-		880	1667	82	28	372	144	28	7.4

[a]Based upon grab sampling between March and September, 1983. (Two to nine sample analyses depending upon the parameter.)
[b]Refer to Tables 1 - 3 for additional site characteristics.
[c]Approximate percent of design flow in parentheses.
[d]Statistics based upon the averages determined for each of the eleven systems shown.

The STE concentrations of organic materials and solids at the six restaurants were found to be substantially higher than those of domestic STE, while other parameters were similar (Table 5). Biodegradable organic matter content as measured by BOD_5, was approximately 380 percent higher and total suspended solids were about 200 percent higher in restaurant STE as compared to domestic STE (Table 5). The STE compositions at establishments other than strictly restaurants exhibited BOD_5 contents approximately 148 percent higher than that of domestic STE, but the concentrations of the other measured parameters were similar or somewhat lower (Table 5).

Table 5. Comparison of Commercial STE Versus Domestic STE.

Parameter	Unit	Commercial STE[a] Restaurant Only	Commercial STE[a] With Other Facilities	Household STE	Community STE[b]
BOD_5	mg/L	506 (3.83)[c]	196 (1.48)	132	118-189
COD	mg/L	1027 (2.31)	419 (0.94)	445	228-284
TSS	mg/L	177 (2.03)	73 (0.84)	87	41-50
TKN	mgN/L	66 (0.80)	46 (0.56)	82	-
TP	mgP/L	20 (0.91)	13 (0.59)	22	-
pH	-	5.5-7.0	6.0-7.4	7.3	6.4-7.8
Fecal Coli	Log#/L	7.0-8.4	6.4-7.8	6.45	-
Oil/Grease	mg/L	83	39	-	16-45
Source		Sites 1,2,3,5,7,9	Sites 4,8,10,11,12	Harkin, et al. 1979	Bowne, 1982

[a]Average results of establishment averages shown in Table 4.
[b]Range of average values measured at three small communities.
[c]Ratio of commercial STE to household STE shown in parentheses.

Soil Absorption System Performance: The average hydraulic loading rates measured in this study ranged from 0.3 to 3.7 cm/d of total horizontal soil infiltrative area (Table 6). These rates were less than typically recommended for design according to current practice (Wisc. Adm. Code, 1980; USEPA, 1980). Despite this fact, five of the twelve systems studied were judged to have performed poorly based upon substantial STE ponding and system surcharging during a dose (Sites 7, 9, 4, 6, 8), with three of these exhibiting surfacing effluent (Sites 6, 7, 8). Poor performance of the five systems is speculated to be due, in large part, to excessive mass loadings of organic matter. Previous researchers have demonstrated that the rate of soil clogging is highly correlated with the cumulative mass loadings of these materials (Jones & Taylor, 1965; Laak, 1970). If the mass loadings are sufficiently high, they may lead to severe soil clogging such that effluent ponding develops to the point where surfacing effluent or plumbing backups occur. The organic loading rates measured in this study ranged from 1.0 to 11.2 gm BOD_5/m^2d. Four of the systems performing poorly were loaded with BOD_5 at rates in excess of 4.5 gm/m^2d. This rate is more than twice as high as that typically applied to soil absorption systems for domestic STE (Table 6). Average suspended solids loadings ranged from 0.4 to 4.0 gm SS/m^2d. At most sites, the suspended solids loadings were similar to those applied in domestic systems (Table 6).

Another potential factor adversely affecting performance of the systems studied may have been that all but two of the twelve were beds, mostly characterized by low length to width ratios (Table 3). The five poorly performing systems were all beds. One of the two trench systems studied (Site 10) was loaded at very high hydraulic and mass loading rates, but performed satisfactorily (Table 6). The trench design may have provided better performance than that which would have been experienced with a bed design. Trenches generally offer greater infiltrative surface area and improved system aeration in comparison to beds.

LABORATORY INVESTIGATION

Subsurface soil absorption of restaurant wastewater was investigated in the laboratory utilizing sand lysimeters. This experiment was carried out in laboratories of the U.W. Civil Engineering Department at the University of Wisconsin between July and December 1983.

Table 6. Summary of Soil Absorption System Loading and Performance.

Type	Site No.[a]	System Type[b]	System Size (m^2)	System Loading: Hydraulic (cm/d)	System Loading: Organic $\frac{gm\ BOD_5}{m^2\ d}$	System Loading: Solids $\frac{gm\ ss}{m^2\ d}$	Infiltration Performance[c]
Restaurant	1	IGGT	604	0.3	1.9	0.6	2
	2	IGGB	876	-	-	-	3
	3	IGGB	1449	0.4	3.8	1.7	3
	5	IGGB	1254	-	-	-	2
	7	IGPB	249	1.2	8.2	1.5	0,2[d]
	9	IGPB	334	1.8	4.6	1.2	1
Motel Complex	4	IGGB	1905	2.9	4.9	1.9	1
	6	IGPB	1951	3.7	-	-	0
Country (Golf) Club	8	IGPB	325	-	-	-	0
	10	IGPT	390	3.3	11.2	4.0	2
	11	IGPB	279	1.0	1.0	0.4	3
Bar/Grill	12	MB	149	1.1	2.0	0.9	2
Domestic[e]	-	MB	38	1.5	2.0	1.3	3

[a]Refer to Tables 1 to 3 for establishment characteristics.
[b]IGGT = Inground gravity trench (conventional), IGGB = Inground gravity bed (conventional), IGPB = Inground pressure bed, MB = Mound with bed, IGPT = Inground pressure trench.
[c]Rating Scale: 0 = hydraulically failed; 1 = mostly flooded but handling daily flow; 2 = intermittent ponding or partial system ponding; 3 = no ponding.
[d]First bed failed, replacement system ponded after two months.
[e]Single family home STE (Harkin et al., 1979).

Materials and Methods

Lysimeter Characteristics: Septic tank effluents were obtained from a local single family home and a restaurant (System No. 5) and applied to sand lysimeters at two hydraulic loading rates, 5.1 and 9.2 cm/day. The lower rate was equal to that normally recommended for sizing of soil absorption systems installed in soils of sand texture (Wisc. Adm. Code, 1980; USEPA, 1980). Duplicate lysimeters were used for each of the four experimental conditions: home STE at the low and high rates, restaurant STE at the low and high rates.

The lysimeters were fashioned from 10 cm diameter clear acrylic pipe to simulate conventional subsurface soil absorption systems. The sand utilized had an effective size of 0.6 mm and a uniformity coefficient of 1.6. Approximately 5 cm of coarse gravel (2.5 cm) were placed in the bottom of each lysimeter, followed by 5 cm of fine gravel. Moist sand was then added to a total depth of approximately 79 cm. A 15 cm layer of coarse gravel was then placed on the sand surface. The saturated hydraulic conductivity (Ksat) of each lysimeter was measured using tap water applied under a 15 cm ponding head. The Ksat's of the four home lysimeters averaged 142 m/d, with a standard deviation of 12 m/d, while those of the four restaurant lysimeters averaged 140 m/d, with a standard deviation of 4.6 m/d. The lysimeters were mounted in the laboratory and maintained in darkness, except during routine servicing and monitoring.

The air temperature within the lab was not controlled and during the experiment gradually decreased in response to seasonal decreases from approximately 30°C to 20°C.

Septic tank effluents (STE's) were manually collected from a local restaurant and a single family home every three days and refrigerated at 5° to 8°C. Each afternoon approximately 7.6 L of each STE were transferred to 20 L reservoirs feeding an automatic dosing system. Twice daily, at approximately 10 A.M. and 8 P.M., STE was applied to each lysimeter.

Monitoring Procedures: The operation of the lysimeters was monitored on a daily basis. The number of wastewater doses to each set of lysimeters (home, restaurant) was automatically recorded using electrical event counters. The occurrence and magnitude of any wastewater ponding was measured. Once continuous ponding occurred to a depth of 15 cm, excess wastewater exited each lysimeter via an overflow port. This overflow was collected and its volume measured each day.

Samples of each STE were taken from the volumes collected for feeding the lysimeters and analyzed for selected physical and chemical parameters according to Standard Methods (1980). The effluent from each lysimeter was collected on the fifteenth and thirty-fifth day after start up and analysis were performed for selected chemical and physical parameters.

Results

Septic Tank Effluent Composition: The composition of the two STE's applied to the lysimeters (Table 7) were representative of household and restaurant STE's (Table 5). The average concentrations of BOD_5 and TSS in the restaurant STE were approximately 2.7 times higher than that in the household STE (Table 7). As a result, the average mass loadings of BOD_5 and TSS in 5.1 cm/d of household STE were equal to those in approximately 1.8 cm/d of restaurant STE.

Table 7. Lysimeter Influent and Effluent Compositions.[a]

Parameter	Units	Home					Restaurant				
		STE	H1	H2	H3	H4	STE	R1	R2	R3	R4
BOD_5	mg/L	140	-[b]	-	-	-	377	-	-	-	-
COD	mg/L	356	88	102	56	24	772	132	85	22	44
TOC	mg/L	196	66	68	55	40	270	80	66	64	84
TSS	mg/L	88	12	22	26	50	247	14	26	19	21
TVSS	mg/L	61	10	4	12	8	173	1	4	8	12
TKN	mg-N/L	48	-	-	-	-	30	-	-	-	-
NH_4N	mg-N/L	42	2	1	1	1	16	1	1	1	1
NO_3N	mg-N/L	0	46	58	55	52	1	26	31	34	24
P	mg-P/L	12	-	-	-	-	15	-	-	-	-
Oil/ Grease	mg/L	38	-	-	-	-	101	-	-	-	-
pH	-	6.6-7.4	-	-	-	-	5.7-6.8	-	-	-	-
Loading Rate	cm/d	-	9.2	9.2	5.1	5.1	-	9.2	9.2	5.1	5.1

[a]Average STE composition based upon results of 2 to 9 analyses: Average of two lysimeter effluent samples collected after fifteen and thirty-five days of STE loading.
[b]"-" indicates analyses not performed.

Infiltration Rate Characteristics: The infiltration rates (IR's) of the lysimeters receiving household STE were reduced by 9 to 37 percent after 67 days of effluent application. Final IR's remained in excess of 94 m/d. Throughout the study, each dose of STE rapidly infiltrated into the media and the sand surface remained exposed to air. After 67 days of operation, STE application to the household lysimeters was terminated.

Shortly after initiation of the experiment, drastic reductions occurred in the IR's of the restaurant lysimeters. Within eight days of effluent application, the IR's of the two lysimeters receiving 9.2 cm/d of restaurant STE (R1, R2) were reduced to less than 0.2 percent of initial rates. Continuous inundation or ponding of the sand surface occurred in R2 after only eight days of loading and in R1 after 21 days. Continuous ponding in the two restaurant lysimeters receiving 5.1 cm/d of STE occurred after 23 days of loading. Hydraulic failure was considered to occur when the ponding depth surpassed 15 cm and lysimeter overflow first occurred. For all four restaurant lysimeters, hydraulic failure occurred after only 29 days of operation or less.

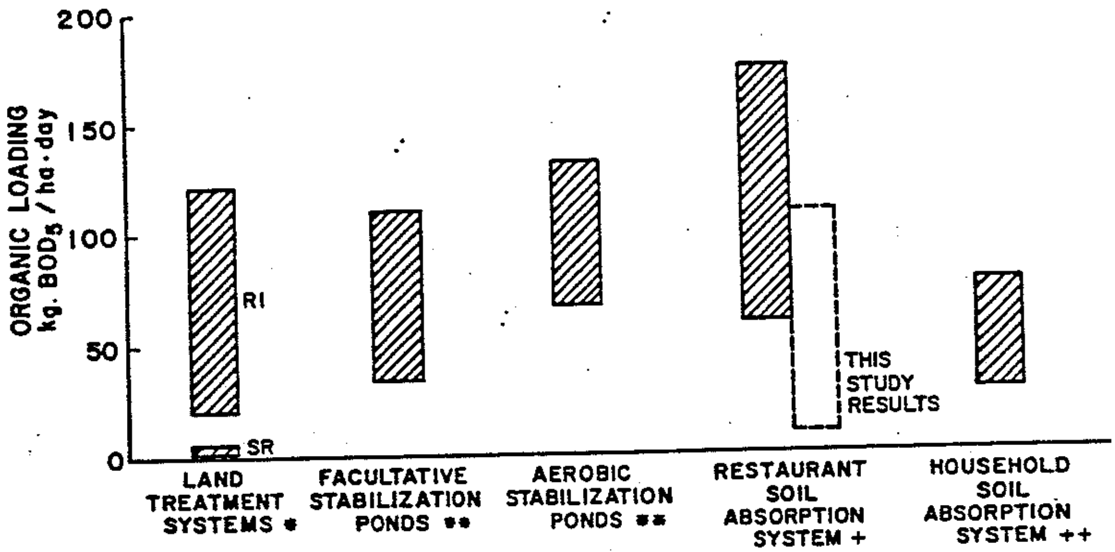
Purification Characteristics: Infiltration and percolation of STE through the sand media in all lysimeters achieved substantial reductions in organic materials and suspended solids and near complete nitrification of the applied ammonia nitrogen (Table 7). The effluent from the restaurant lysimeters was not markedly different from that of the household lysimeters. This indicated that the restaurant lysimeters achieved greater removals of organic matter and suspended solids. Accompanying greater removal, however, is the need for greater degradation of the removed materials. If the soil system is overloaded with organic matter and suspended solids, system failure may result. This undoubtedly was a major factor in the early hydraulic failure of all four restaurant lysimeters.

SUMMARY AND CONCLUSIONS

The results of field and laboratory investigations demonstrated that the performance of on-site wastewater treatment and disposal systems receiving wastewater from commercial establishments can be markedly different from that of systems receiving household wastewater. Even after treatment in grease interceptors and multiple septic tanks, some commercial wastewater effluents contained substantial concentrations of biodegradable organic materials, suspended solids, grease, nutrients and bacteria (Table 4). Compared to households, the septic tank effluent (STE) at restaurants contained substantially higher concentrations of organic matter (506 mg/L BOD_5) and suspended solids (177 mg/L TSS) (Table 5). Commercial establishments with substantial non-restaurant wastewater sources (e.g. motel, country club) exhibited less concentrated STE compared to restaurant. With the exception of organic matter concentration (196 mg/L BOD_5), these establishments exhibited STE concentrations similar to or lower than household STE.

The design of conventional and alternative subsurface soil absorption systems typically consists of soil system sizing based solely on established hydraulic loading rates for soils of different characteristics. The concentrations or mass loadings of constituents, such as BOD_5 or suspended solids, are generally not considered in design. This practice can result in alarmingly high mass loading rates. For example, recommended organic loading rates (BOD_5) for design of several types of treatment systems are shown in Figure 1, along with the organic loading rates associated with subsurface soil absorption systems. As illustrated, the rates potentially encountered in some commercial systems designed based on hydraulic load can exceed those generally recommended for land treatment systems, facultative stabilization ponds and even aerated stabilization ponds.

Of particular interest is the comparison of subsurface systems and land treatment systems (Figure 1). Slow-rate irrigation and rapid infiltration systems are typically designed to receive average hydraulic loadings of primary municipal wastewater effluent of about 2 and 10 cm/d respectively. However, to facilitate long-term operation, the design of these systems limits organic loading as well as other constituent loading rates and system operation allows for resting intervals as well as periodic maintenance of the soil infiltrative surface (USEPA, 1981). In contrast, subsurface system design does not explicitly limit organic loading and system operation does not generally allow for prolonged resting intervals or periodic maintenance.



* Typical Range of Values for (EPA, 1981) Rapid Infiltration (RI) and Slow-Rate (SR) Systems.
**Typical Range of Design Values (Metcalf & Eddy, 1972).
\+ Range of Design Values Based on Hydraulic Loadings of 1.6-4.9 cm/d and Average Wastewater Quality Measured in this Study. Range of Values Measured in this Study.
++Range of Design Values Based on a Hydraulic Loading of 1.6-4.9 cm/d and Average Wastewater Quality from Table 5.

Fig. 1. Comparison of Design Organic Loading Rates for Various Various Wastewater Treatment Systems.

The results of this study suggest that hydraulic loading rate should not be the sole design parameter. The mass loading of other parameters, such as BOD_5 and solids may also be critical with maximum loading rates based on soil morphology and system design. For systems of bed geometry installed in sands, maximum loading rates may be in the range of 2.0 cm/d, 4.5 gm $BOD_5/m^2/d$ and 1.7 gm $TSS/m^2/d$ (Table 6). Higher hydraulic loadings may be feasible as regards infiltration as long as applied organic and solids loadings are maintained below acceptable levels. Higher bottom-area hydraulic and mass loading rates may also be appropriate for systems of shallow narrow trench design due to the increased infiltrative area and system aeration afforded by this geometry.

The purification capacity of subsurface soil absorption systems for restaurant STE was investigated under laboratory conditions using sand lysimeters. A limited data base collected over a short period of operation indicated that the composition of restaurant effluent after percolation through approximately 79 cm of medium-coarse sand was generally similar to that of household effluent after the same soil treatment. The purification actually achieved under field conditions over the long-term are currently unknown.

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