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GREYWATER TREATMENT BY COARSE MEDIA FILTRATION OF SEPTIC TANK EFFLUENT

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by

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In-House waste segregation has been proposed as a method of enhancing conventional onsite disposal methods and facilitating the development of alternatives. The elimination of the garbage grinder, and handling of the toilet wastes with an alternative toilet system would reduce the wastewater flow volume and pollutant load of residential households to that of the greywater. Characterization studies have demonstrated that the greywater fraction is not innocuous and must be properly managed [1-12]. However, management of the greywater may be simplified over that of total household wastewater due to a reduced flow volume; a reduced mass of pollutants to be removed, particularly suspended solids and nitrogen; and a reduced potential for pathogenic contamination. Although diverse strategies have been proposed for greywater management, rigorous field evaluations to properly assess the feasibility of most have not been conducted.

A field study is in progress at the University of Wisconsin to evaluate the performance of selected greywater treatment methods. The primary processing scheme under study consists of a 525 gal septic tank, intermittent coarse sand filter and an iodine disinfection module. The objectives of this study are to provide a detailed characterization of the total greywater influent, delineate the greywater effluent quality produced by the unit processes employed, assess the suitability of the effluent for various disposal/reuse functions, identify the operation and maintenance requirements necessary for the achieved effluent quality and estimate system costs. This paper contains a discussion of the research accomplished to date including preliminary results.

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MATERIALS AND METHODS

Research Facility Characteristics

Site Characteristics --

The greywater treatment facilities were installed at a rural residence whose characteristics are detailed in Table 1. To facilitate the investigation of greywater treatment, the existing plumbing system at the dwelling was

Table 1. Residence Characteristics

Occupants	- 4
Adults	- 2
Children(Age)	- 2 (4, 1.5 yr)
Construction	- Existing, ranch style
Floors	- 1
Toilets	- 1
Bath tub w/ shower*	- 1
Automatic clotheswasher*	- 1
Water softener	- Manual
Sinks*	- Kitchen, bathroom, laundry
Water Supply	- Well
Waste Disposal	- Septic tank - drainfield

*Sources of greywater used in study.

altered so that the greywaters from all sinks, bath tub/shower, and clotheswasher (Table 1) were collected and transported separately from the dwelling. To eliminate any contamination of the greywater system, a new collection network was installed for the greywater with the toilet wastes and water softener regeneration wastes transported in the existing network.

Unit Process Characteristics --

The greywater treatment facilities were installed outside of the residence as shown in Figure 1, by project personnel with the aid of a local contractor. A description of each unit process follows.

Septic Tank -- The septic tank utilized was one of the smallest commercially available units in the area. It was a precast concrete tank, approximately 5.5 ft in diameter with a liquid depth of 3.0 ft and a total liquid volume of 525 gallons. The inlet and outlets from the tank were baffled with semicircular fibreglass baffles attached to the tank wall around the inlet and outlet,

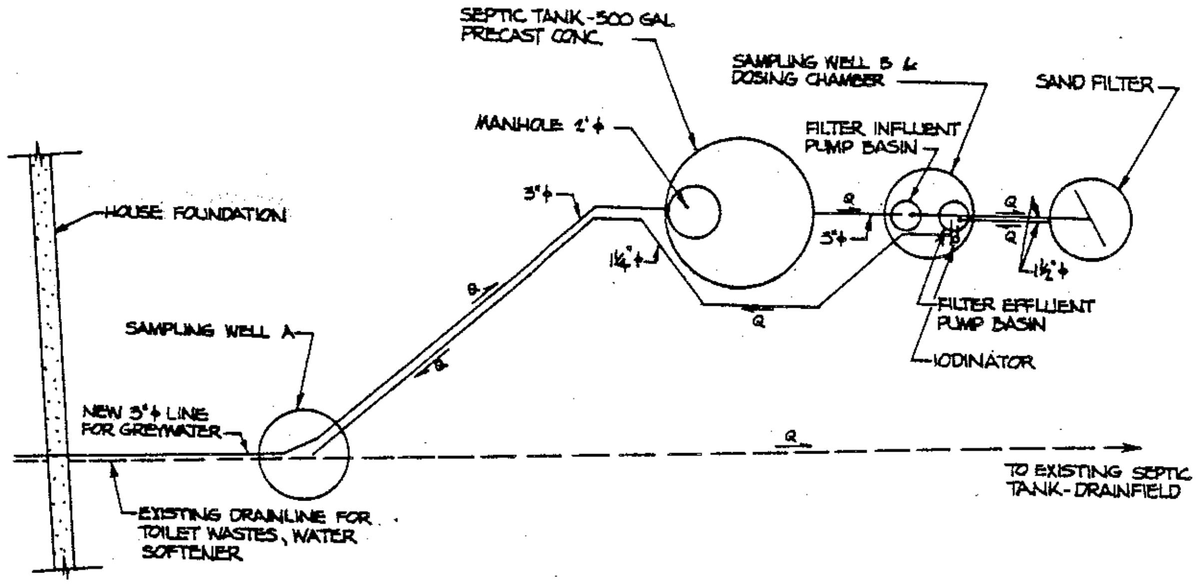

Figure 1. Greywater Treatment Research Facilities

respectively. The baffles extend approximately 0.5 ft above and 0.75 ft below the liquid surface at both the inlet and outlet.

Sand Filter -- At the onset of the project, a great deal of effort was expended in selecting and obtaining the media to be used in the sand filter. Achieving a relatively high quality effluent while obtaining reasonably long filter runs ($\geq$ 1 year) was a primary consideration. Further, high loading rates were desirable to minimize the filter surface area required. Several previous investigations with total household wastewater and domestic wastewater had shown that a filter possessing these characteristics was possible [13,14]. The media finally selected was a coarse filter sand obtained from American Materials Co., Eau Claire, WI. Characterization of the sand media included particle size distribution [15], bulk density [15], porosity [15] and moisture retention properties [16]. An estimate of the initial saturated hydraulic conductivity of the sand media was made by measuring the outflow rate from a two-inch diameter sand column 27 inches in height loaded with tapwater under a head of approximately 2 in. The results of these analyses are presented in

Table 2 and Figure 2.

Table 2. Sand Media Characteristics

Source	American Materials Co. Eau Claire, WI.
Effective Size	1.37 mm
Uniformity Coefficient	1.30
USDA Classification	Coarse sand
Bulk density	1.54 gm/cm^3
Porosity	41%
Saturated conductivity	11,800 gpd/ft^2

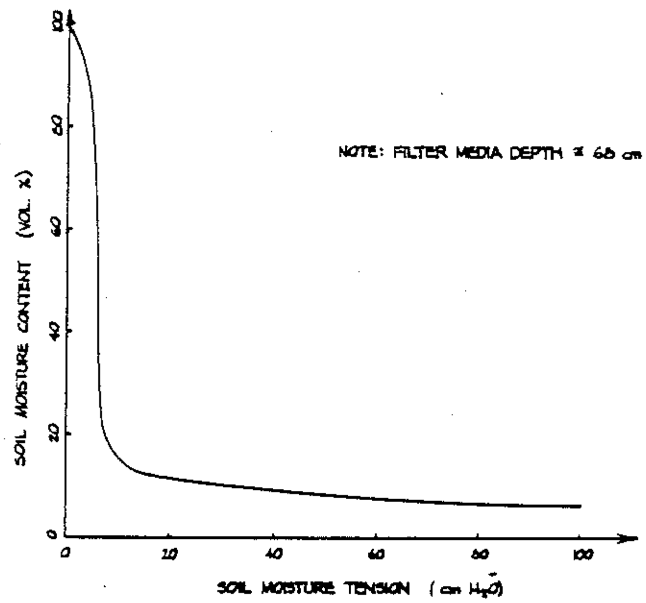

Figure 2. Sand Media Moisture Retention Properties

In sizing the filter, the greywater flow from the study residence was projected to be in the range of 75 gpd based on the results of previous characterization studies [1-12] and several water meter readings taken at the site. An average daily loading rate of approximately 7.5 gpd/ft^2 was selected requiring a filter surface area of 10 ft^2. This daily loading was designed to be applied in intermittent doses of approximately 1.25 gal/ft^2, with the actual dosage schedule and daily loading determined by the greywater generation patterns within the residence.

The characteristics of the sand filter are detailed in Figure 3. The basin used was a 280 gal polyethylene brine tank with the following dimensions: diameter = 3.5 ft, surface area = 9.6 ft^2, depth = 4.0 ft. A section of 1.5 inch diameter plastic pipe with 0.312 inch diameter holes in it served as the underdrain. Approximately 6 inches of 1 inch, washed hard-rock overlain by 4 inches of 0.25 inch pea gravel served as the support media for approximately 27 inches of the filter sand. The filter basin was covered with a removable cover insulated with two-inch foam.

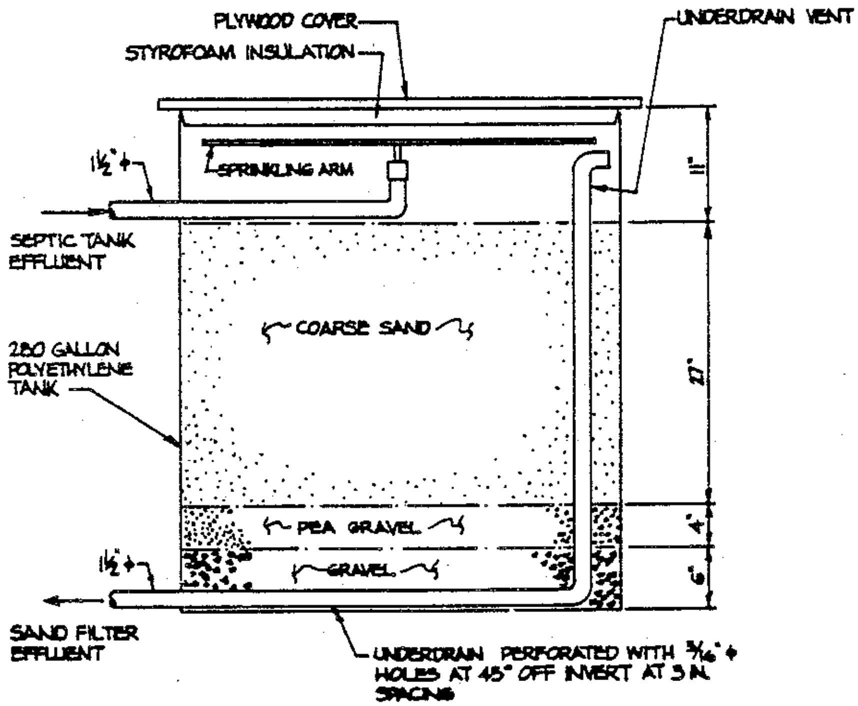

Figure 3. Sand Filter Profile View

Uniform distribution of the septic tank effluent (STE) over the filter surface was deemed critical to maximize its performance, particularly due to the coarse media utilized. Initial attempts to distribute the STE through high rate application (40 gpm) onto a splash plate located at the center of the filter proved ineffective. A rather simple yet relatively effective method of applying the STE over the filter surface was finally devised using a rotating sprinkler arm as detailed in Figure 4.

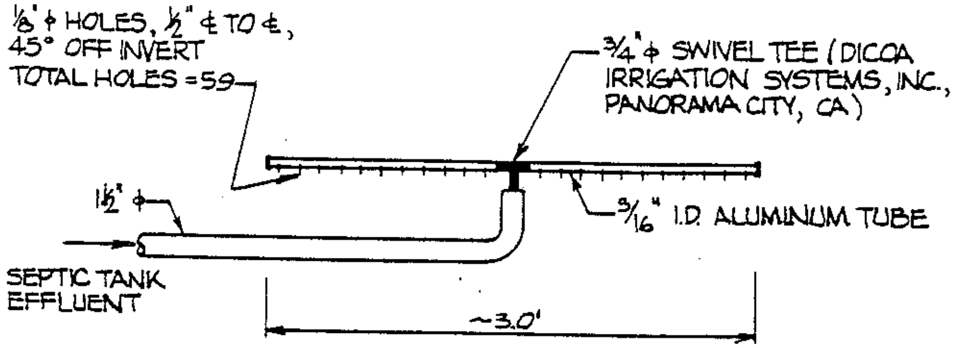

Figure 4. Sand Filter Distribution Arm Detail

Sampling Wells and Pump Basins -- To enable sampling of the raw greywater stream, a sampling well was installed. This well consisted of a 6 ft section of 4 ft diameter corrugated culvert pipe buried vertically and capped with an insulated removable cover. The sewer pipe used to transport the raw greywater was directed into and through this well on its course to the septic tank. Inside the well, no-hub couplings were utilized so that a section of the greywater sewer pipe could be removed, enabling collection and sampling of the raw greywater.

Two, 1.5 ft diameter polyethylene pump basins were utilized as part of the filter system. Both were installed in a buried chamber consisting of a 6 ft section of 4 ft diameter corrugated culvert pipe buried vertically and capped with an insulated removable cover. One basin was utilized to collect STE for application to the filter. This basin contained a small submersible sump pump (Peabody Barnes, Model SSC 26, 1/3 hp) controlled by a mercury float switch. The high and low levels of the float were set to yield a discharge volume of approximately 10 gal. The actual dose volume to the filter during each application cycle was equal to this 10 gal plus any influent flow to the pump basin during the application cycle. The average discharge rate to the filter was approximately 7.7 gpm.

The second pump basin was utilized to collect effluent from the sand filter and to serve as a contact chamber for the iodine disinfection process. This basin also contained a small submersible sump pump controlled by a mercury float switch. The high and low levels of this float were set to yield a discharge volume of approximately 8.8 gal. The majority of the effluent was discharged at a rate of 21 gpm to the existing septic tank-soil absorption system. An adjustable portion was directed to the iodine disinfection module as described in the following section.

Iodine Saturator -- An iodine saturator was selected as a simple yet effective method of disinfecting the sand filter effluent [10,11]. The saturator (Iodinamics Corp., PA), designed to operate as a batch process, was installed as shown in Figure 5. Each time the pump in the SFE sump basin was activated, a portion of the discharge was directed to the feed reservoir for the saturator. An adjustable overflow in the feed reservoir allowed the volume passed through the saturator each cycle to be controlled. This feed volume coupled with its iodine concentration determined the iodine dose applied to the SFE.

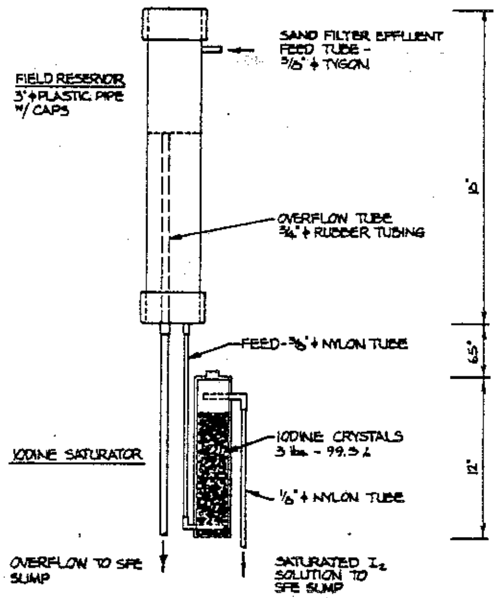

Figure 5. Iodine Disinfection Module

The concentration of a saturated iodine solution varies dramatically with temperature, from 150 mgL at 0°C to 400 mgL at 30°C to 1100 mgL at 60°C, for example [18]. It was anticipated that the average wastewater temperatures encountered in this study would be in the 10°C range where the saturated iodine concentration would be approximately 200 mg/L. To achieve the 5-10 mgL iodine dose deemed necessary required that 1.2 L of a 200 mgL iodine solution be added to the SFE sump basin after each pump cycle. To accomplish this, of the 8.8 gal (33.3 L) discharged from the SFE sump each cycle, 0.32 gal (1.2 L) or 3.6% was returned through the iodination module yielding a iodine dose of approximately 7.2 mg/L in the SFE sump. The contact time afforded in the SFE sump was dependent on the outflow rate from the sand filter and the frequency at which STE was applied to it.

Raw Greywater Characterization

Quantitative characterization of the greywater flow was accomplished using water use data collected at the site. To determine total water use, a water meter (Badger Recordall, Model 15) was installed on the incoming water supply to the home. The standard register on this meter was modified to provide an electrical switch closure after each 5 gal increment of water use. This was accomplished by attaching a small bar magnet onto the register dial needle and positioning two proximity reed switches (spst) above it at the 2.5 and 7.5 gallon positions on the dial. As water was used, the needle rotated. As the needle passed by each proximity switch, the switch was temporarily closed by the magnet. This switch closure activated an electrical impulse counter and one channel on a four-channel strip-chart recorder (Cole Parmer Instrument Co., Model 8364-30). This modified register was tested in the laboratory and field, and found to record flow within 0.5 percent of a similar unmodified register.

Toilet usage was monitored continuously with a flow-indicating switch (Gems Delaval, Model FS-200, 0.5 gpm actuation) installed in the water supply line serving the toilet. Each time the toilet was flushed, water flow through the switch activated an electrical impulse counter and a second channel on the strip-chart recorder. The toilet was calibrated using the main water meter to identify the volume/flush and enable the toilet water usage to be obtained from the toilet usage data. Exterior water use and softener regeneration water use were recorded by the homeowner on data sheets provided.

The greywater flow to the treatment system was readily determined from total water use less that water used for exterior purposes, toilet use and water softener regeneration. Analysis of the strip charts from the event recorder in combination with the homeowner data sheets allowed quantitative characterization based on daily and even hourly measurement periods.

Twenty-four hour flow composited samples of the raw greywater were collected periodically as follows. Raw greywater was directed into a 1.5 ft diameter polyethylene basin located in well A (Figure 1). A small submersible pump located in this basin discharged its contents each time approximately 10 gal of greywater accumulated. The bulk of the 10 gal was discharged to the greywater septic tank, while a portion of it was directed back into the sump basin to mix its contents. Another portion was directed to a 3 gal sample container stored at 4°C. The flow-composited samples were transported back to the University of Wisconsin where analyses were performed for physical, chemical and microbiological parameters according to procedures outlined in Standard Methods [19].

Unit Process Operation and Maintenance

The operation of the greywater treatment processes was closely monitored. The characterization of the influent greywater was accomplished as described previously. Additionally, each application of STE to the sand filter was recorded by an electrical impulse counter and one channel of the strip-chart event recorder.

Changes in the hydraulic conductivity of the sand media were subjectively monitored by visual observation of the sand surface routinely as well as after a dose was applied, to determine the existence and degree of any ponding. Quantitative monitoring was accomplished periodically by measuring the outflow rate from the sand filter after a dose was applied.

The power consumption by the pumps was measured using a separate kilowatt-hour meter. Any maintenance required by the unit processes was recorded in an operations log.

Unit Process Effluent Quality

The effluent quality achieved with each unit process was determined through periodic sampling. Twenty-four hour flow-composited samples of septic tank effluent were obtained by directing a portion of each dose to the sand filter, to a 1 gal sample container stored at 4°C. Samples of the sand filter effluent prior to installation of the iodinator were obtained in a similar manner. After installation of the iodinator, samples of the iodinated SFE were then collected.

All flow composited samples were transported back to the University of Wisconsin where analyses were performed for chemical, physical and microbiological parameters according to procedures outlined in Standard Methods [19]. Grab samples of tapwater, STE, SFE, iodinator feed solution, and iodinated SFE were also obtained periodically and analyzed *in situ* for temperature, pH, and dissolved oxygen and then returned to the University of Wisconsin for further analyses.

Site Preparation

The interior plumbing alterations and the installation of most of the unit process equipment and monitoring apparatus was made by October 16, 1979, at which time raw greywater was directed to the septic tank. On November 27, 1979, STE application to the sand filter was initiated. Prior to this time the STE had been discharged directly to the existing soil disposal system. On February 15, 1980, the iodinator module was installed and iodination of the SFE was initiated.

RESULTS AND DISCUSSION

The preliminary results generated to date in this study are presented in this section. At the time of this writing the iodination module had just been installed and no results are available for that unit process.

Raw Greywater Characterization

The average daily water use determined from readings taken off the water meter and the electrical event counters during periodic site visits are presented in Table 3. In this table, the raw greywater flow calculated from the other water use information is also presented. The results obtained from analyzing actual daily flow measurements obtained from the event recorder strip-charts are presented in Table 4.

Table 3. Water Use/Wastewater Production Summary*

Parameter	Unit	Data Pts.	Mean	Range	
				Low	High
Data Collection Interval	days	26	3.7	1.0	12.9
Interior Water Use	gpd	25	107.8	43.0	231.0
	gpcd	25	27.0	11.0	58.0
Toilet Use	npd	26	6.6	4.4	10.3
	npcd	26	1.6	1.1	2.6
	gpd	26	28.3	18.9	44.3
	gpcd	26	7.1	4.7	11.1
Softener Use	gal/use	3	55	-	-
	gpd	2	1.7	-	-
	gpcd	2	0.4	-	-
Greywater**	gpd	25	77.8	40.5	197.7
	gpcd	25	19.4	10.1	49.4

* Based on readings taken from water meter and event counters during periodic site visits from 10-26-79 to 2-1-80.

** Estimated flow based on greywater ≃ interior use - toilet use - softener use.

Table 4. Daily Water Use/Wastewater Production*

Parameter	Unit	Data Pts.	Mean	S.D.	95% Confidence Interval	Range
Interior Use	gpd	25	106.8	49.6	86.0-127.5	40-250
	gpcd	25	26.7	12.4	21.5-31.9	10-62.5
Toilet Use	npd	25	6.6	2.0	5.8-7.5	3-11
	npcd	25	1.6	0.5	1.4-1.9	0.7-2.8
	gpd	25	28.6	8.7	25.0-32.1	12.9-47.3
	gpcd	25	7.2	2.2	6.2-8.0	3.2-11.8
Greywater**	gpd	25	76.2	50.5	55.4-97.0	14.2-228.5
	gpcd	25	19.0	12.6	14.0-24.2	3.6-57.1

* Based on actual daily measurements obtained from the strip-chart recorder during 10-24-79 and 1-29-80.

** Estimated flow based on greywater ≃ interior use - toilet use - softener use.

The per capita results measured for all forms of water use/wastewater flow at the site were somewhat lower than values reported by several previous investigations [1-12]. This may have been due to the two small children residents who most likely did not contribute an equal share to the water use at the site, but who were included in the per capita calculations.

The results of analyses of a limited number of raw greywater samples are presented in Table 5. These analyses indicated that the greywater flow from the residence contained substantial quantities of oxygen demanding substances as well as suspended solids. Further, very high concentrations of total and fecal coliforms were isolated, suggesting a potential for pathogenic contamination of the greywater. These high levels may have been due to children related greywater events, particularly the washing of diapers. The qualitative characteristics measured for this greywater are similar to those predicted from the results of previous investigations [1-10].

Table 5. Raw Greywater Quality*

Parameter	Unit	Data Pts.	Mean	Range
BOD_5	mg/L	3	263	145-324
COD	mg/L	4	593	548-646
TSS	mg/L	4	165	100-204
TKN	mg-N/L	3	12.2	5.9-18.4
TP	mg-P/L	4	6.3	2.8-7.8
Turbidity	NTU	3	68	50-98
Hardness	mgCaCO	3	46	40-52
Alkalinity	mgCaCO	2	376	304-528
pH	-	2	-	7.3-8.7
Total Coliforms	No./L	3	9.7×10^7	2.4×10^7-3.8×10^8
Fecal Coliforms	No./L	3	2.3×10^7	2.1×10^7-2.5×10^7

* Unless otherwise noted, results presented are based on analyses of 24-hour flow composited samples taken during 1-14-80 and 2-18-80.

Unit Process Operation and Maintenance

The average daily flow processed through the septic tank was approximately 78 gpd (Table 3). The average detention time in the tank was 7.1 days, based upon its liquid volume of 525 gal. The sand filter loading between startup (November 27, 1979) and the date of this writing (February 15, 1980) has totalled approximately 6,285 gal, applied in a total of 518 doses. Application to the filter during this 80 day period averaged 6.5 doses/day at 1.26 gal/ft^2/dose resulting in a unit loading of 8.2 gpd/ft^2. Individual filter dosings and daily loadings varied depending upon the greywater generation pattern in the home. For example, for those days where daily flow measurements were made (Table 4), the daily loading ranged from 1.5 to 23.8 gpd/ft^2.

Visual observation of the sand filter surface to date has indicated that some reduction in filter hydraulic conductivity (FHC) has taken place. Initially, no STE ponded on the sand surface even during a dose. Recently, however, ponding of an applied dose has occurred. This ponding is very slight, occurring only in small depressions in the sand surface, and dissipating almost immediately after cessation of the dose. An estimate of the magnitude of the reduction in FHC has been made through periodic measurement of the outflow rate from the filter. The results of these measurements are presented in Figure 6. Throughout the period covered, the dose cycle remained constant at 1.4 min. As shown in Figure 6, the conductivity through the filter has been reduced. Between November 27, 1979 and February 15, 1980, the time required for 50% of the applied dose to pass through the filter has increased from approximately 7 min to 16.2 min, a 130 percent FHC reduction. This reduction is most likely due to two factors: 1) reorientation and packing of the sand particles, and 2) clogging of the pore spaces by solids filtered out of the wastewater and produced by biological activity in the filter. Of these two, the latter was judged to be far more important.

Biological activity within the sand filter was minimal during initial operation, as evidenced by the relatively stable outflow rates (Figure 6) and the low removal efficiencies (Table 7). This was felt to be somewhat the result of the coarse media employed and the high loading rates, but more the result of the low temperatures encountered. The influent wastewater temperature was relatively constant at 10°C while the air temperature over the sand surface fluctuated between 2°C and 10°C, approximately. On January 11, 1980, after 45 days of operation, supplementary heat was applied to the air space over the filter surface to increase the temperature and try to stimulate

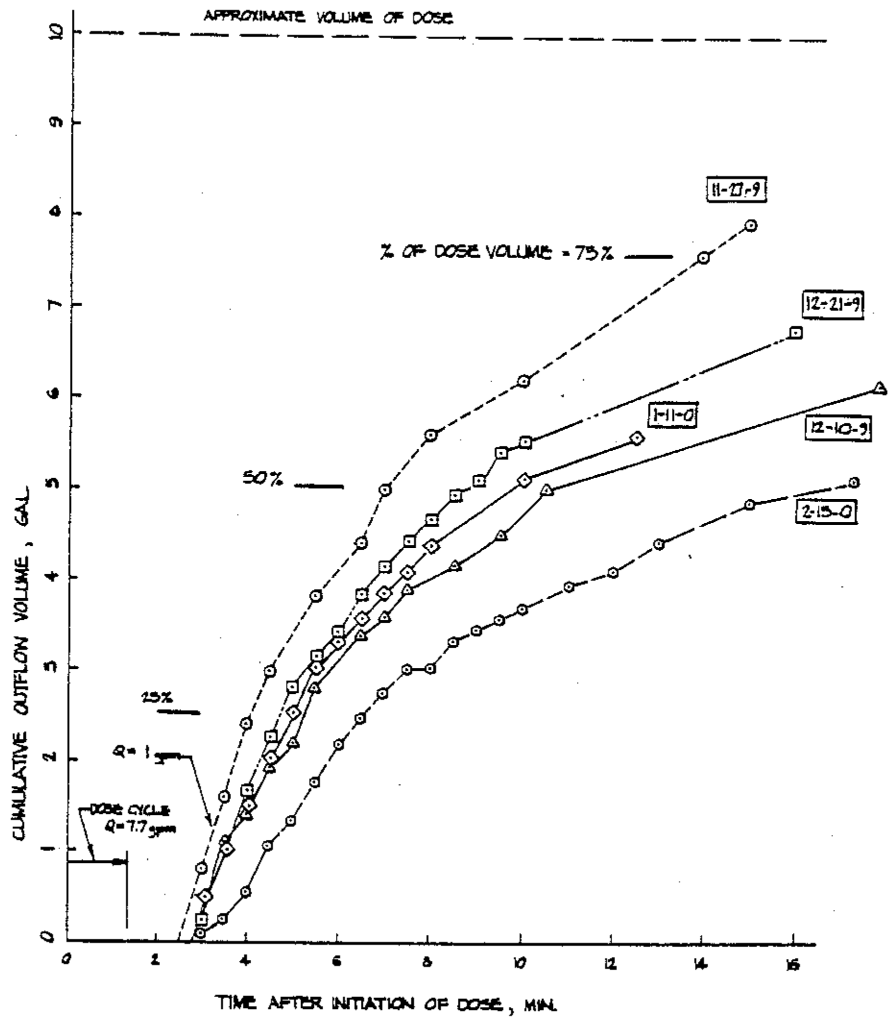

Figure 6. Sand Filter Outflow Rate Measurements

biological activity. This was accomplished by placing a 33 ft coil of heating wire (100 watt output) on the sand surface. After this, air temperatures over the sand surface stabilized at 10°C. As shown in Figure 6, the hydraulic conductivity of the filter did decrease substantially after this supplementary heat was added. It is not known at this time, whether the reduction in conductivity was solely the result of additional operation days of the filter, the increased temperatures, or some combination thereof.

The power consumption of the treatment system prior to installation of the heating wire on the sand filter was measured to be 0.28 kwh per dose or approximately 0.023 kwh per gal of STE processed. The installation of the heating wire created an additional power consumption of 2.4 kwh per day.

As of this writing essentially no maintenance has been required by any of the unit processes. The sprinkler arm on the sand filter has experienced some minor orifice clogging. However, the degree of this has been very minor as evidenced by the fact that the dose time to the filter has remained constant; to date no maintenance has been performed.

Unit Process Effluent Quality

The effluent quality achieved by the septic tank and sand filter are presented in Table 6, with the percent removals for selected parameters given in Table 7. The septic tank effluent quality characteristics measured to date in this study are within the range of the limited data presented previously [10,20]. As shown in Table 7, the conventional septic tank has produced only limited removals of the pollutants measured.

The effluent quality characteristics produced by the sand filter to date have been poor. Removals of BOD_5 and suspended solids have averaged only 63 and 3 percent, respectively and essentially no nitrification has occurred. Previous investigations had indicated removal efficiencies higher than those obtained in this study to date [13]. Effluent quality data collected to date from the sand filter has indicated an improving performance since startup, and especially after the application of supplementary heat. Further operation of the filter is necessary to adequately delineate its effluent quality characteristics.

Table 6. Unit Process Effluent Quality*

Parameter	Unit	Septic Tank Effluent			Sand Filter Effluent		
		Data Pts.	Mean	Range	Data Pts.	Mean	Range
BOD_5	mg/L	7	193	123-293	5	71	35-122
COD	mg/L	7	445	159-631	6	234	205-313
TSS	mg/L	4	58	50-64	3	56	32-80
TKN	mg-N/L	7	20.5	14.7-26.3	6	12.4	6.0-21.2
NH_3-N	mg-N/L	5	11.6	9.3-13.4	5	6.1	0.7-10.3
NO_2+NO_3-N	mg-N/L	5	0.1	0.11-0.47	5	0.1	0-0.4
TP	mg-P/L	2	5.9	4.5-7.3	2	5.3	3.2-7.4
Turbidity	NTU	6	51	47-58	6	20	8-29
Hardness	$mgCaCO_3/L$	5	57	52-64	4	74	60-112
Alkalinity	$mgCaCO_3/L$	6	388	350-408	6	376	294-432
pH	-	3	-	6.8-7.0	3	-	6.8-7.1
Total Coliforms**	No./L	7	1.4×10^8	$2.7 \times 10^7 - 8 \times 10^8$	6	3.2×10^7	$2.6 \times 10^6 - 8 \times 10^8$
Fecal Coliforms**	No./L	7	1.3×10^7	$4.5 \times 10^6 - 5.4 \times 10^7$	6	2.0×10^6	$2 \times 10^5 - 5 \times 10^7$

* Unless otherwise noted, results presented are based on analyses of 24-hour flow composited samples taken during 11-27-79 to 2-18-80.

** Mean values based on log-normalized data.

Table 7. Unit Process Removal Efficiencies*

Parameter	Units	Raw Greywater Mean	Septic Tank Mean	Septic Tank %R	Sand Filter Mean	Sand Filter %R**
BOD_5	mg/L	263	193	27	71	63
COD	mg/L	593	445	25	234	47
TSS	mg/L	165	58	65	56	3
TKN	mg-N/L	12.2	20.5	<0	12.4	40
TP	mg-P/L	6.3	5.9	6	5.3	10
Turbidity	NTU	68	51	25	20	61
Total Coliforms	No./L	9.7×10^7	1.4×10^8	<0	3.2×10^7	77
Fecal Coliforms	No./L	2.3×10^7	1.3×10^7	43	3.0×10^6	77

* Based on the results shown in Tables 5 and 6.

** Based on STE quality.

SUMMARY

A field study is in progress at the University of Wisconsin to evaluate the performance of selected greywater treatment methods. The primary processing scheme studied to date has included a 525 gal septic tank, intermittent coarse sand filter and an iodine disinfection module. Preliminary results from this investigation are outlined below.

1. The raw greywater flow was found to contain substantial quantities of oxygen-demanding substances as well as suspended solids (Table 5). Further, high concentrations of total and fecal coliforms were also measured (Table 5). These high levels have been attributed in large part to children related greywater events in the home, particularly the washing of diapers.

2. Treatment of the raw greywater through a conventional septic tank (525 gal) with a detention time averaging approximately 7 days has provided only limited removals of pollutants (Table 7).

3. Treatment of the greywater STE through a coarse sand filter (E.S. = 1.37 mm, U.C. = 1.30) was accomplished in an average of approximately 6.5 intermittent doses/day at 1.26 gal/ft^2/dose for a total daily loading of

8.2 gpd/ft^2. After nearly 3 months of operation, the hydraulic conductivity of the filter media has been reduced by approximately 130 percent as determined through periodic outflow rate measurements (Figure 6). While no ponding of the sand surface was achieved during initial operation, slight ponding of the surface was observed after 80 days of operation.

4. The effluent quality produced by the sand filter has been generally poor (Table 6). This has been attributed to the coarse media and high loading rates employed, as well as limited biological activity in the filter. The limited biological activity is felt to be due to the low environmental temperatures encountered (influent wastewater ≈ 10°C, filter surface air ≈ 2°C-10°C). To remedy this condition, after 45 days of filter operation, supplementary heat was applied to the filter surface air space using heating wire laid on the surface. The air temperature was increased somewhat and biological activity appears to be increasing as evidenced by decreased outflow rates and improving effluent quality.

5. A iodine saturator was employed to provide for disinfection of the sand filter effluent. This unit process has only been in operation a short time and no performance data was available at the time of this writing.

Further investigation of the greywater treatment system described in this paper is ongoing. Additional investigations into greywater treatment are also planned, including: laboratory bench-scale treatability studies; a field evaluation of the impact of recirculation on the performance of the coarse sand filter; a field evaluation to compare the treatment efficiency of a small sedimentation basin (retention time at peak hourly flow of 1 to 6 hours e.g.) to that of the 525 gal septic tank; and a field evaluation to evaluate the performance of other sand media sizes.

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