POLICY DEVELOPMENT FOR GREYWATER TREATMENT AND REUSE

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INTRODUCTION

Greywater includes household waste water, except that originating from toilets and garbage disposal units. Typical sources include kitchen sinks, dishwashers, bathtubs and showers, clothes washers, and others (Siegrist, 1977). One particular basis for interest in greywater treatment and reuse has been the potential to lessen the quantity of wastewater which actually requires disposal, for reasons such as alleviating overloading of disposal systems (Kane, 1981). The perception has been widespread that public health agencies have poorly developed guidelines for evaluating greywater treatment and reuse systems. This lack of guidelines is thought to explain the view that public health agencies are poorly receptive to greywater systems in the United States.

OBJECTIVES

The objective of this study was to analyze existing literature on greywater characteristics as well as treatment and reuse systems, in order to develop guidance for public health policy applicable to greywater treatment and reuse. The study was limited to small systems applicable to domestic sources of greywater. It was recognized from the earliest stages of study that available information might not be sufficient to support a fully developed public health policy. In this case, the study was intended to develop whatever preliminary policy guidance that could be supported.

METHODOLOGY

Since the study was only intended to analyze existing information, the methodology was simple. Initial access to literature was obtained by contacting the Environmental Protection Agency, the National Sanitation Foundation, the University of Wisconsin-Madison (the location of research on certain greywater treatment and reuse systems), and the National Appropriate Technology Assistance Service. The latter source provided a computer search of data bases. These initial contacts led to the literature search.

QUANTITY OF GREYWATER

Table 1 lists the water use by fixture (or appliance), based on a study of five homes occupied by middle income families in Boulder, Colorado (Bennett and Lindstedt, 1975). The study showed that water use which would produce greywater averaged 29.0 gallon/day/capita, which was 65.2 percent of all water use. Although these data are interesting, an evaluation of the quantity of greywater generated also should consider the effect of urban versus rural location, as well as socioeconomic level and other factors. Notably, most interest in greywater has been rural.

Table 1

Individual Appliance Water Use

Appliance	Mean Gal. per Use	Uses per Person Per Day (Avg. 3.8 people/home)		Gal./Day
Toilet	4.1	All people	3.6	14.7
		Adults (21+ yr.)	4.5	
		Teenagers (13-20)	2.4	
		Children (1-12)	2.4	
Sink	1.7	All people	4.5	7.6
35% Kitchen		Adults (21+ yr.)	5.8	
65% Bath		Teenagers (13-20)	2.9	
		Children (1-12)	3.1	
Garbage Disposal	2.1	All people	0.40	0.8
Bath and Shower	27.2	All people	0.32	8.7
		Adults (21+ yr.)	0.27	
		Teenagers (13-20)	0.76	
		Children (1-12)	0.16	
Dishwasher	6-7	All people	0.15	1.1
Washing Machine	28.6	All people	0.30	11.6
		Adults (21+ yr.)	0.29	
		Teenagers (13-20)	0.09	
		Children (1-12)	0.32	
TOTAL WATER USE PER DAY		All people	44.5	
		Adults (21+ yr.)	49.0	
		Teenagers (13-20)	41.0	
		Children (1-12)	34.0	

(Adapted from Bennett and Lindstedt, 1975).

Table 2 presents mean water consumption for various fixtures and appliances, again based on a study of five families (Laak, 1975). In this case, water consumption which would lead to greywater generation constituted an average of 52.2 percent of total use of 41.4 gallon/day/capita.

Table 2
Mean Water Consumption Rates from a Study of Five Families

Family	Kitchen Sink		Bathtub		Bathroom Sink		Laundry Machine		Toilet		Total	
Name	GPCD	%	GPCD	%	GPCD	%	GPCD	%	GPCD	%	GPCD	%
A	3.2	4.9	15.4	23.5	3.0	4.6	14.3	21.9	29.5	45.0	65.4	100
B	9.1	16.3	5.3	9.4	3.2	5.7	2.1	3.7	36.4	65.0	56.1	100
C	3.4	13.0	5.9	22.3	1.5	5.6	4.3	16.3	11.2	42.8	26.3	100
D	2.1	7.1	5.0	16.8	1.0	3.4	7.9	26.6	13.7	46.2	29.7	100
E	2.1	6.5	10.0	30.9	2.7	8.2	4.5	13.8	13.2	40.6	32.5	100
Ave. (Wgtd)	3.6	9.0	8.5	20.7	2.1	5.1	7.4	18.4	19.8	46.7	41.4	100
Range	2.1-9.1	4.9-16.3	5.0-15.4	9.4-30.9	1.0-3.2	3.4-8.2	2.1-14.3	3.7-26.6	11.2-36.4	40.6-65.0	26.3-65.4	100

1 gal/capita/day = 3.785 liters/capita/day (From Laak, 1975).

Table 3 is an adaptation of information assembled by R. Siegrist from a number of studies. Summarized values for water use showed that water use related to greywater generation was 62.5 percent of total use of 46.4 gallon/day/capita (Siegrist, 1978).

The data in these studies did not show the relation between water consumption and amount of wastewater generated. It is probable that one important reason for this is that few houses in the United States have plumbing that segregates greywater from blackwater.

Table 3
Water-Use Characteristics

Fraction	Event	Gal./Use	Use No. per Cap./Day	Gal./Cap./Day
Greywater	Bath/Shower	24.5[a] (2,4,5)[b]	0.42 (2,4,5)	9.2 (1-5)
	Clothes Washing	37.4 (2,4,5)	0.29 (2,4,5)	10.0 (1-5)
	Dishwashing	8.8 (2,4,5)	0.35 (2,4,5)	3.2 (2,4,5)
	Miscellaneous	-		6.6 (2,4,5)
	Total	-	-	29.0 (1-5)
Garbage	Garbage Grinding	2.0 (2,4)	0.58 (2,4)	1.2 (2,4)
Blackwater	Toilet	4.3 (1,2,4,5)	3.5 (1,2,4,5)	16.2 (1-5)

NOTE: Liters = 3.8 x gallon. Gal./Cap./Day may not equal Gal./Use multiplied by Uses/Cap./Day due to difference in number of study averages used to compute the mean shown.

a - Mean of study averages.

b - References included in determining mean and/or range: (1) Cohen and Wallman, 1974; (2) Ligman et al., 1974; (3) Laak, 1975; (4) Bennett and Lindstedt, 1975; and (5) Siegrist et al., 1976 (Adapted from Siegrist, 1978).

PHYSICAL, CHEMICAL, AND MICROBIOLOGICAL CHARACTERIZATION OF GREYWATER

Tables 4-A and 4-B give data for comparing tap water with bath water and laundry water which resulted from its use. Particular increases were seen in both waters for levels of ammonia, total organic carbon, color, turbidity, and total solids (Hypes, 1974). The laundry water also showed changes in chlorine, phosphate, sulfate, sodium, and conductivity.

Table 4-A: Chemical/Physical Characteristics Obtained from Bath Water Tests

		Baseline	Bath Water & Nonbiocidal Soap				Bath Water & Biocidal Soap			
		Tap	1	2	3	4	1	2	3	4
Characteristic	**Unit**	**Water**	(a)	(a)	(b)	(b)	(a)	(a)	(b)	(b)
					Metals					
Arsenic	ppm	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Barium	ppm	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Boron	ppm	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Cadmium	ppm	< 0.005	0.01	0.005	0.005	0.01	0.01	0.005	0.007	0.009
Chromium	ppm	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	ppm	0.1	0.1	0.1	0.1	0.1	< 0.1	0.1	0.1	0.1
Iron	ppm	0.2	0.5	0.2	< 0.2	< 0.2	0.2	< 0.2	< 0.2	< 0.2
Lead	ppm	0.1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Magnesium	ppm	2.4	2.4	2.3	2.2	2.1	2.3	2.2	3.8	2.9
Manganese	ppm	0.01	0.03	0.01	0.02	0.02	0.03	0.03	0.03	0.02
Mercury	ppm	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.002	< 0.002
Nickel	ppm	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Potassium	ppm	1.6	6.6	5.2	4.0	3.5	3.7	4.5	4.4	3.1
Selenium	ppm	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.04	< 0.04
Silver	ppm	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Sodium	ppm	8	23	19	10	10	24	18	17	12
Zinc	ppm	0.6	0.7	0.6	0.7	0.7	0.7	0.5	0.4	0.4
					Ions					
Ammonia	ppm	< 0.2	0.9	1.6	0.7	2.1	0.8	0.7	1.2	1.0
Calcium	ppm	31	28	29	28	28	28	30	32	37
Chloride	ppm	25	30	30	23	22	22	18	18	17
Chlorine	ppm	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.1	0.1	0.1	0.1
Cyanide	ppm	< 0.02	0.03	0.02	< 0.02	< 0.02	0.04	0.02	0.02	0.02
Fluoride	ppm	1.0	1.0	0.8	0.8	0.7	0.6	0.6	0.6	0.7
NO_3, NO_2	ppm	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Phosphates	ppm	0.1	0.1	0.2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06
Sulfates	ppm	35	70	60	35	30	25	30	10	35
					Organics					
MBAS	ppm	< 0.02	0.02	0.1	0.1	0.1	0.2	0.03	0.29	0.25
Phenols	ppm	< 0.05	0.06	0.06	< 0.05	< 0.05	0.1	0.1	0.05	0.07
Total Organic Carbon	ppm	20	134	89	25	20	106	39	—	—
Urea	ppm	<50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
					Physical Properties					
Color - $PtCl_6$ = Units		< 5	>100	>100	20	10	>100	>100	>100	50
Conductivity-μmhos/cm		290	300	310	240	220	260	230	235	235
Odor	Subjective	No	No	No	No	No	No	No	Yes	No
pH	pH Units	7.2	7.2	7.5	7.2	7.3	7.3	7.2	7.4	7.3
Suspended Solids	ppm	<100	113	124	<100	<100	164	114	<100	<100
Total Solids	ppm	220	460	341	203	236	804	722	280	221
Turbidity(Si02 equivalent)	ppm	2	250	290	20	15	175	125	115	45

a From shower baths.
b From tub baths.
(From Hypes, 1974).

Table 4-B: Chemical/Physical Characteristics Obtained from Laundry Water Tests

Characteristic	Unit	Baseline Tap Water	Combined Wash Cycle/ Rinse Cycle Sample 1	Combined Wash Cycle/ Rinse Cycle Sample 2	Separate Wash Cycle Sample 1	Separate Wash Cycle Sample 2
Metals						
Arsenic	ppm	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Barium	ppm	< 1	< 1	< 1	< 1	< 1
Boron	ppm	< 1	< 1	< 1	< 1	< 1
Cadmium	ppm	< 0.04	< 0.04	0.005	0.01	0.005
Chromium	ppm	< 0.01	0.04	0.01	0.05	0.05
Copper	ppm	< 0.1	0.1	0.1	0.1	0.1
Iron	ppm	0.2	0.4	0.4	0.4	< 0.2
Lead	ppm	< 0.05	0.5	0.2	0.1	0.2
Magnesium	ppm	2.4	2.9	2.7	3.5	3.5
Manganese	ppm	0.01	0.02	0.02	0.02	0.02
Mercury	ppm	< 0.2	< 0.2	0.3	0.2	< 0.2
Nickel	ppm	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Potassium	ppm	1.3	4.1	4.5	7.9	6.6
Selenium	ppm	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Silver	ppm	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Sodium	ppm	10	100	84	191	144
Zinc	ppm	0.5	0.5	1.2	1.9	1.0
Ions						
Ammonia	ppm	0.4	1.2	1.9	5.8	2.9
Calcium	ppm	27	27	25	40	32
Chloride	ppm	18	41	44	68	64
Chlorine	ppm	< 0.05	0.4	0.3	0.8	0.5
Cyanide	ppm	< 0.02	< 0.02	< 0.03	0.06	0.05
Fluoride	ppm	1.0	1.1	1.2	1.3	1.3
No_3, NO_2	ppm	< 0.5	1.5	1.9	1.5	1.8
Phosphates	ppm	0.7	350	150	420	300
Sulfates	ppm	30	144	110	175	300
Organics						
MBAS	ppm	0.04	66	38	137	108
Phenols	ppm	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Total Organic Carbon	ppm	13	75	75	225	100
Urea	ppm	< 50	< 50	< 50	< 50	< 50
Physical Properties						
Color - $PtCl_6$ =	Units	10	60	40	(c)	50
Conductivity-μmhos/cm		230	450	270	850	700
Odor	Subjective	Yes	Yes	Yes	Yes	Yes
pH	pH Units	7.2	7.9	7.7	7.8	7.5
Suspended Solids	ppm	<100	500	100	100	<100
Total Solids	ppm	170	600	500	1100	1000
Turbidity (SiO_2 equivalent)	ppm	6	14	38	85	60

c Unable to quantify because of extensive blue color interference. (From Hypes, 1974).

Table 5 reports data summarized by Boyle et al., based on five studies of contributions of major pollutants. The greywater accounted for 45.1 percent of the biochemical oxygen demand, 24.3 percent of the suspended solids, 17.0 percent of the nitrogen, and 70 percent of the phosphorous (Boyle et al., 1982). The high content of biochemical oxygen demand in the wastewater is largely due to the kitchen sink, though organic material in greywater may be more easily biodegradable (Siegrist, 1978). The high amount of phosphorous in greywater, normally 55 to 85 percent, is largely due to laundry (Winneberger, 1976).

Table 5

Pollutant Contributions of Major Residential Wastewater Sources[a] (grams/cap./day)

Parameter	Garbage Disposal	Toilet	Basins, Sinks Appliances	Approximate Total
BOD_5	18.0	16.7	28.5	63.2
Suspended Solids	26.5	27.0	17.2	70.7
Nitrogen	0.6	8.7	1.9	11.2
Phosphorous	0.1	1.2	2.8	4.0

[a]Means of results reported in Olsson et al., 1968; Ligman et al., 1974; Bennett and Lindstedt, 1975; Laak, 1975; and Siegrist et al., 1976. (Adapted from Boyle et al., 1982).

Boron is a particular concern in contamination of greywater, especially if it is to be used for irrigation, since some laundry wastewater contains sufficient amounts to be toxic to certain plants (Ayres et al., 1977).

Table 6 lists levels of indicator bacteria (Siegrist, 1978), based on studying wastewater from clothes washing and bathing in six residences. Levels for total coliforms, for example, showed a mean of 1810 per 100 ml, which would be far less than values for total domestic sewage. However, another study of six greywater samples showed a mean of 1.95×10^7 coliforms per 100 ml (Hypes, 1974). One worker suggested that greywater contributes 50 to 70 percent of the total coliforms in total domestic sewage (Olsson et al., 1968).

Table 6

Bacteriological Characteristics of Bath and Laundry Wastewaters[a]

Event	Organism	Samples	Mean No./100 ml
Clotheswashing	Total Coliforms	41	215
	Fecal Coliforms	41	107
	Fecal Streptococci	41	77
Bathing	Total Coliforms	32	1810
	Fecal Coliforms	32	1210
	Fecal Streptococci	32	326

[a]The results shown are from in-house sampling at six residences. (Adapted from Siegrist, 1978).

It is evident that a wide range of values can be expected for microbiological contamination. However, the presence of E. coli and Enterococci has been suggested as an indicator of probable fecal contamination, and thus potential for pathogenic microorganisms to be present (Siegrist et al., 1976). However, it was suggested that the high fecal coliform levels did not necessarily indicate the presence of elevated levels of pathogens (Brandes, 1978).

REUSE OF GREYWATER

Use of greywater for irrigation is based on evidence that it contains significant amounts of the primary nutrients (nitrogen, phosphorus, and potassium), as well as some 13 other substances (Ayres et al., 1977). However, household cleaners can add harmful substances (Withee, 1977), which are most easily manageable by careful choice of household products. Substances particularly likely to cause problems include chloride, sodium (Rawlings, 1980), and as previously noted, boron. Withee suggested 500 mg/l of chloride as an acceptable maximum for small scale irrigation.

Problems which can result from irrigation with greywater are due to accumulation of salt and alkaline substances in soil (Javits, 1978). One aspect of the problem of excess alkalinity is that certain nutrients (such as iron, manganese, and copper) may become fixed and unavailable to plants (Donahue, 1971). Excess salt can have toxic effects on plants as well as lessen porosity of soil, impeding air and water movement.

Regarding microorganisms, the soil is often an unfavorable environment for some pathogens. Such organisms may face adverse conditions of temperature and moisture, and must compete with natural microorganisms of soil. Organisms may be trapped in clays (Hypes, 1974), or be removed by mechanisms such as filtration (Nykiel, 1983). The most effective soils for treatment of wastewater include clays, and those high in organic matter.

Other alternatives may exist for reuse of greywater. The "suds saver" system reuses laundry water itself in clothes washers. Flushing water closets also would be a possible use for greywater.

TREATMENT OF GREYWATER

Siegrist compared treatment of greywater to that of total domestic sewage, using septic tank treatment followed by sand filtration. Reduction in biochemical oxygen demand was 72 percent and 79 percent for greywater and domestic sewage, respectively. Reduction in suspended solids was 85 percent and 89 percent (Siegrist, 1978). Several studies have shown effective treatment of greywater using septic tank - intermittent sand filtration systems. Alternating use of filters extends the lifespan of the system, allowing the resting filter to more fully aerate. However, a need was seen for disinfection of the effluent (Sauer, 1975; Boyle et al., 1982; Nykiel, 1983).

Cohen and Wallman reported on evaluation of treatment systems using diatomite filters and cartridge filters. Both of these, supplemented by disinfection with chlorine, produced effluents which met criteria under National Sanitation Foundation Standard 41, which relates to flushing water (Cohen and Wallman, 1974).

Disinfection is appropriate both with regard to the intended use of the greywater, as well as to avoid operational problems (such as growth of microbiological masses and production of odors in holding tanks). One suggestion was that the dose of chlorine be sufficient to provide a free residual of 0.5 mg/l after contact time of one hour (Clivus Multrum, 1982). Other treatment methods also have been proposed for greywater. However, an important limitation exists in that simple, dependable systems are appropriate for small applications. Further, this review involved only a few systems that were regarded as typical.

THE PRESENT SITUATION IN STANDARDS FOR GREYWATER

Although microbiological characteristics of greywater no doubt pose the most significant public health concern, no extensive research was found on contamination of greywater by pathogenic microorganisms. Using greywater for flushing can give substantial savings in water use, but deserves careful consideration (Siegrist and Boyle, 1981). Disinfection and filtration would be desirable as a minimum to avoid transmission of disease and avoid interference with the functioning of toilet mechanisms (Anderson et al., 1981).

Use of greywater for irrigation raises concerns of pollution of ground water, contaminated runoff, human contact, and vector breeding (Milne, 1976). Desirable safeguards include pretreating the greywater (in septic tanks, perhaps) (Brandes, 1978; Nykiel, 1983) as well as avoiding contact with edible portions of plants (Warshall and Ferraro, 1977). Generally, it appears that risks to health can be minimized by limiting greywater reuse to non-contact applications, such as irrigation and toilet flushing.

Public health agencies cite such problems as lack of data, concern about whether maintenance will be provided for recycling systems, and other points (Siegrist, 1977). Presently, greywater normally must be handled only by conventional systems, such as public sewers and individual disposal systems.

Some standards exist or can be adapted. Bailey et al., presented standards for reuse, based on partially treated total domestic wastewater. See Table 7 (Bailey et al., 1969). California developed water reuse standards, again based on total wastewater. See Table 8 (Milne, 1976). The National Sanitation Foundation published Standard 41, which included guidelines for devices that process blackwater and greywater from places of human occupancy. See Table 9 (Anderson et al., 1981).

Table 7

Summary of Recommended Water Quality Standards (Limits in mg/l)

	USPHS Drinking Water Standards (mandatory limit) A	Bathing Waters	General Washing and Cleaning	Irr. Waters	Toilet Flushing Waters
Turbidity	5	10	10	10	20
Color*	10	15	15	15	30
Odor	3	3	3	3	6
Ag	(0.05)**	0.05	0.05	0.05	--
As	0.01 (0.05)	0.01 (.05)	0.05	0.05	--
Ba	--(1.0)	--(1.0)	1.0	1.0	--
B	--	--	--	1.0	--
Cd	--(0.01)	0.01	0.01	0.01	--
Cl	250	500	500	500	--
Cr	--(0.05)	0.05	1.5	0.05	--
Cu	1	2.0	2.0	1.0	1.0
CCE	0.2	0.2	0.4	0.4	--
CN	0.01 (0.2)	0.2	0.2	0.2	--
F	--	6.0	6.0	6.0	--
Fe	0.3	1.0	1.0	1.0	1.0
Pb	--(0.05)	0.05	0.05	0.05	--
Mn	0.5	0.05	0.05	0.5	0.5
Fe + Mn	--	1	1	1	1.0
NO_3	45	90	180	180	--
Phenols	0.0001	0.005	0.01	0.05	--
Se	(0.01)	0.01	0.01	0.01	--
SO_4	250	500	500	500	--
TDS	500	500	500	1000	--
Zn	5	10	10	10	--
pH	--	6.0-8.3	6.0-8.3	6.5-8.3	--
Hardness	--	100	100	--	--
Alkalinity	--	60	60	--	--

** Numbers in parenthesis are considered the maximum allowable limits
* Color Units
(Adapted from Bailey et al., 1969).
A Now replaced by National Primary Drinking Water Standards

Table 8

Discharge Standards for Reclaimed Wastewater Based on California Environmental Health Code, Title 22

Reclaimed Water Use	Health Standard
Food crops: spray or surface irrigation	Median coliform count 2.2 per 100 ml.
Landscape irrigation, for lawns, parks, playgrounds or dairy pastures	Median coliform count 23.0 per 100 ml.
Orchards and vineyards, use for fodder, fiber and seed crops, surface irrigation only	0.5 ml per liter per hour settleable solids (i.e., primary treatment)
Extensively processed food crops	Exception to the food crop standard may be granted by Department of Health
Recreational lake, public contact	Median coliform count 2.2 per 100 ml.
Recreational lake, no public contact	Median coliform count 23.0 per 100 ml.

(Adapted from Milne, 1976).

Table 9

NSF Water Quality Standards for Recycling and Reuse Systems

Parameter	Standard 41
Turbidity	90 JTU
Total Coliforms	240 org./100 ml.
BOD_5	45 mg/L as 7 day running ave. 30 mg/L as 30 day running ave.
TSS	45 mg/L as 7 day running ave. 30 mg/L as 30 day running ave.
Odor	non-offensive
Total Residual Cl_2	--

(Adapted from Anderson et al., 1981).

DISCUSSION AND PRESENTATION OF PRELIMINARY POLICY GUIDELINES

Study to date has been limited in characterization of greywater, especially regarding content of pathogens. The study has not been extensive. However, the finding of large numbers of indicator bacteria indicates that greywater is a potential source of pathogens. Nevertheless, treatment by such means as septic tank-intermittent sand filter systems, or by filtration and disinfection, has produced effluents suitable for specific low order uses.

General policy guidelines are suggested as follows:

1. Greywater reuse should be limited to non-contact applications.
2. Use for irrigation of food crops may be allowed, provided that there is pretreatment (reduction in settleable solids to prevent clogging of soil and disinfection), that the greywater is applied in a subsurface manner, and that the greywater is not allowed to contact root crops or edible portions of plants. Further, the irrigation system should be entirely closed.
3. Use for landscape irrigation may be permitted, again, subject to pretreatment for reduction in settleable solids and for disinfection.
4. Use for toilet flushing may be permitted, subject to treatment, including disinfection, to meet the criteria given in Standard 41 of the National Sanitation Foundation.
5. Use of greywater for washing clothes should be limited to greywater originating in the laundry, and in particular to "sud saver" features in washers.
6. Other uses of greywater, such as recreational, may be evaluated on a case-by-case basis, but will not be allowed unless protection of public health is clearly demonstrated.

CONCLUSION

Review of literature revealed interest in greywater treatment and reuse, but lack of fundamental data, especially on the characterization of greywater regarding contamination with pathogenic microorganisms. A research need exists for such characterization, and study should be broadly based, including the wide range of socioeconomic factors which is relevant. Until further information is available, only non-contact uses should be permitted for greywater, such as irrigation and use as a flushing liquid. Even in these cases, appropriate treatment should be required. These guidelines should be considered interim, until more specific information is available.

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