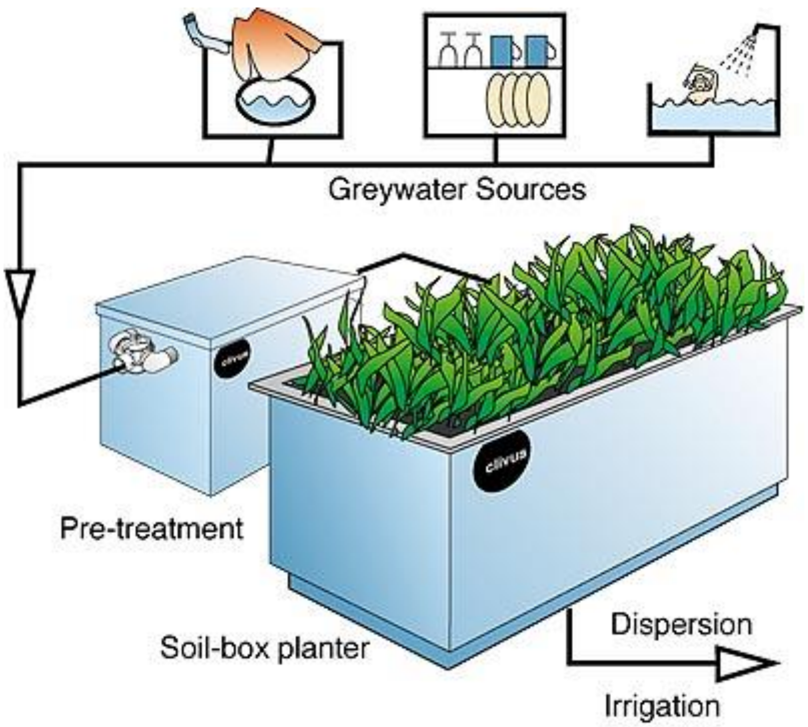
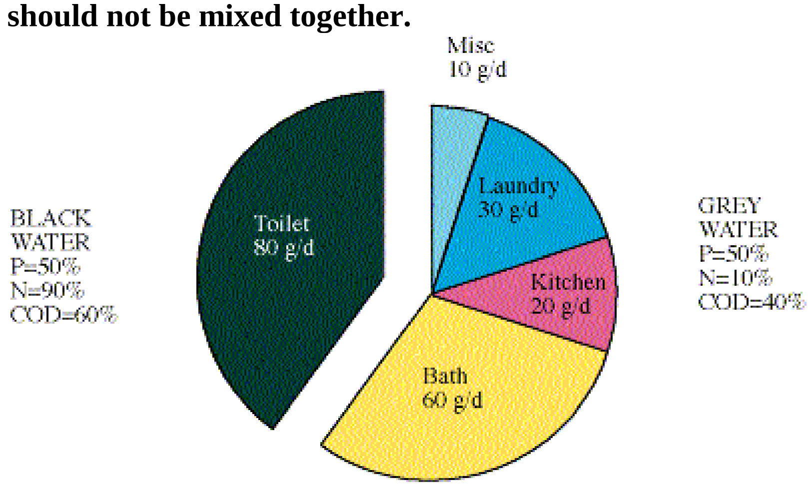
GREYWATER

what it is . . . how to treat it . . . how to use it



Greywater is washwater. That is, all wastewater excepting toilet wastes and food wastes derived from garbage grinders. There are significant distinctions between greywater and toilet wastewater (called "blackwater"). These distinctions tell us how these wastewaters should be treated /managed and why, in the interests of public health and environmental protection, they should not be mixed together.



COMBINED WASTEWATER

Greywater and Blackwater: Key differences

Greywater contains far less nitrogen than blackwater
Nine-tenths of the nitrogen contained in combined wastewater derives from toilet wastes (i.e., from the blackwater). Nitrogen is one of the most serious and difficult-to-remove pollutants affecting our potential drinking water supply.

Greywater contains far fewer pathogens than blackwater
Medical and public health professionals view feces as the most significant source of human pathogens. Keeping toilet wastes out of the wastewater stream dramatically reduces the danger of spreading such organisms via water.

Greywater decomposes much faster than blackwater
The implication of the more rapid decomposition of greywater pollutants is the quicker stabilization and therefore enhanced prevention of water pollution.
(see graphs Fig 2. & 3.).

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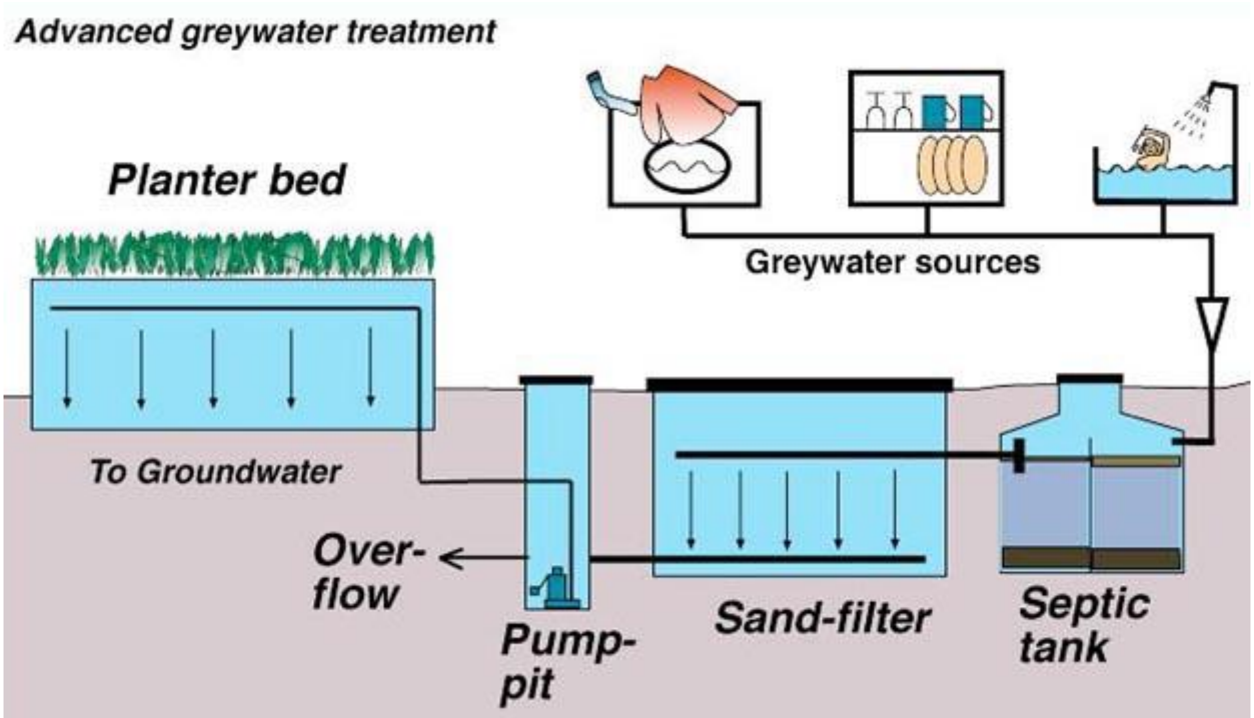
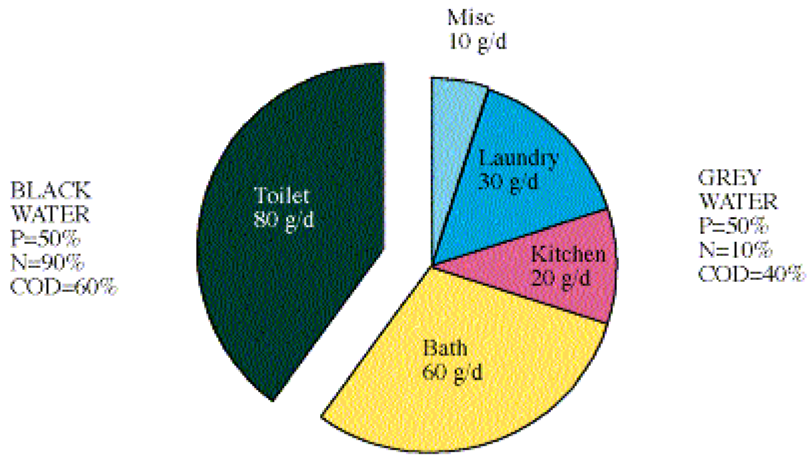


Courtesy of Hans Lönn, Fastighetsanalys, Älgö

Greywater: Synopsis

Conventional sanitary engineering has maintained that "sewage is sewage" whether it be greywater alone or total sewage (grey and blackwater mixed together. There is one reasonable argument for this position: namely, that greywater, if left untreated for a few days, will behave like total sewage. Both will become malodorous (become anaerobic), and both will contain a large number of bacteria. The observation of these common characteristics has given rise to regulations that do not distinguish between the various sources of pollution and which therefore mandate the same treatment for all wastewaters. But the differences between greywater and total sewage are far more important than their similarities, the following document will present an alternative strategy for treating/managing greywater and give the rationale for this approach.



COMBINED WASTEWATER

Greywater is specifically washwater. That is, bath, dish, and laundry water excluding toilet wastes and free of garbage-grinder residues.When properly managed, greywater can be a valuable resource which horticultural and agricultural growers as well as home gardeners can benefit from. It can also be valuable to landscape planners, builders, developers and contractors because of the design and landscaping advantages of on-site greywater treatment/management. It is, after all, the same phosphorous, potassium and nitrogen making greywater a source of pollution for lakes, rivers and ground water which are excellent nutrient sources for vegetation when this particular form of wastewater is made available for irrigation.

Greywater irrigation has long been practiced in areas where water is in short supply. However, proper precautions for its use have not always been observed. This has posed a problem for health officials, who contend that there is no good management method for greywater which both balances user needs with public safety considerations. In fact, options for making safe use of greywater as a source for irrigation are many and diverse. The engineering of these systems is still a relatively young technology; but it is one making rapid progress. It also makes sense from both the environmental and "waste" management points of view. As these systems utilize the nutrient (potential pollutant) content in the effluent, they constitute a real solution to the treatment /management of greywater. "Real solution" here means that these greywater treatment/management systems simply do not generate waste products which, by definition, require disposal.

In the following material, technical as well as practical aspects of greywater irrigation are discussed. The requisite equipment, now commercially available through Clivus Multrum, Inc., is described as is the matter of system-sizing.

Greywater characteristics data cited here are from the most thorough report known on the subject at the present time: "Residential Waste Water" (Hushållsspillvattnet) by Lars Karlgren, Victor Tullander, Torsten Ahl and Eskil Olson. This report was funded by the Swedish National Board for Building Research in 1966 and was published in the magazine *Water* (*Vatten*, 3 -67) in March of 1967. Some of this report's diagrams and data are used here as references. The report is based on separated greywater/blackwater plumbing in an multi-apartment complex in

Stockholm, and data was collected over a period of 12 weeks. The report is based on about 3500 analyses. Of particular interest is its investigation of the BOD-curve characteristics of greywater. It documents the difference in speed of decay over time between greywater and blackwater.

Greywater pollution

Short description of how pollution is measured -- primary and secondary pollution.

Primary pollution

Historically speaking, it was not so very long ago that lakes, rivers and coastal waters were clean and supported a balanced aquatic plant and animal life. As rivers and lakes started to receive organic pollution from industry, sewers, septic systems, and present -day agricultural and livestock-raising practices, these organics decomposed in the water, consuming the oxygen dissolved in it--oxygen crucial for fish and other aquatic animals. This process is known as primary pollution. The commonly used measurement of primary pollution is BOD5 (five-day Biological Oxygen Demand) and COD (Chemical Oxygen Demand)--the amount of oxygen extracted from water by bacteria when pollutants decompose. The more organic material there is in sewage, the greater the amount of oxygen needed to decompose these pollutants and, consequently, the greater the primary pollution.

Secondary pollution

Concommitant with the primary pollution, algae and other "out -of- balance" plant species start to grow as the result of being fertilized by the surge of nutrients from the above-mentioned sources. These fertilized plants, in turn, die and decompose, further robbing the water of its naturally dissolved oxygen. This phase is called secondary pollution (Diagram A), or "eutrophication", and is considerably more damaging to the oxygen level than primary pollution. The principal nutrients causing secondary pollution are nitrogen, phosphorous and potassium. Secondary pollution is measured by how much fertilizer is added to water. To understand their growth potential in water, it is necessary to know which nutrients in it are in short supply in the water. Some lakes are growth-restricted by the lack of phosphorous, others by lack of nitrogen and others, yet again, by the lack of potassium.

Generally speaking, combined sewage is rich in all three nutrients and contributes greatly to unbalanced plant growth in water, be it in a lake, a stream, or an estuary. We also need to see how nutrients are most likely to reach bodies of water -- direct discharge of sewage adds all the nutrients whereas soil infiltration systems primarily add nitrogen which freely travles with the water. In contrast, phosphorous has a propensity for locking on to soil particles by ion-exchange and does not travel to pollute nearby waters as readily.

The diagram below gives a rough idea of primary and secondary pollution derived from flush-toilets and various greywater sources.

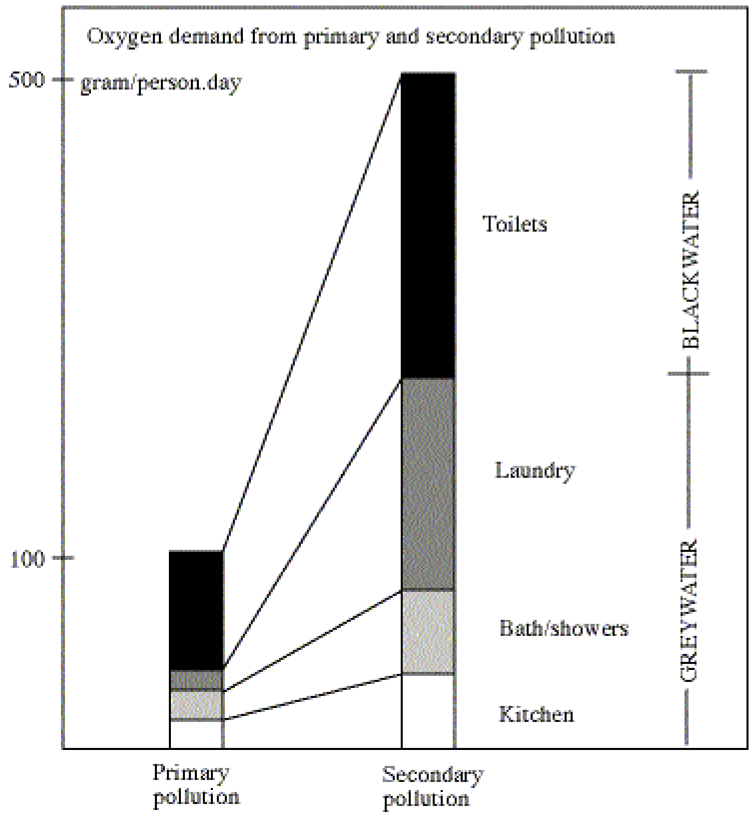


DIAGRAM A.

What distinguishes greywater from blackwater?

Greywater(washwater) sources are found in the kitchen, the laundry, bathrooms/washrooms, sinks, and showers. None of these sources carries water which is likely to contain disease organisms of anywhere the same magnitude as those in toilet wastes. By far the greatest source of pathogens in wastewater is excrement. Urine is sterile save in exceptional circumstances (e.g., grave urinary tract infections). In households with infants in diapers, fecal matter can enter the laundry water, mainly through washing machines that has a pathogen killing effect in themselves by breaking the encapsulation and exposing potential pathogens to detergnets.

Perhaps the most significant difference between blackwater and greywater lies in the rate of decay of the pollutants in each. Blackwater consists largely of organic compounds that have already been exposed to one of nature's most efficient "treatment plants": the digestive tract of the human body. It is understandable that the by-products from this process do not rapidly further decompose when placed in water.

BOD curves

To get an idea of how oxidizable material affects the amount of oxygen in the water over time, BOD-curves should be constructed. Conventional BOD numbers are inadequate for assisting us in understanding how greywater and blackwater differ. Even though many different organic compounds are present in the various waste waters, the process of decomposition is usually described as a monomolecular or first-order reaction. Streeter& Phelps (Rennerfelt, 1958; Tsivoglou, 1958) use the following diffrerential equation:

$dy / dt = k ' (La - y)$

where

La = total biochemical oxygen demand at the time t = 0

y = consumption of oxygen

$k '$ = rate constant for the biochemical oxidation

The smaller $k '$ is, the slower the decomposition. In the Swedish study [Tullander, Karlgren, Olsson] $k ' = 0.1$ for blackwater in the graph below. After 5 days of decomposition, only 40% of the ultimate decomposition has been accomplished. [See Fig. 1] By contrast, the rate constant for greywater is k ' = 0.45 and BOD5 for greywater has reached about 90% of Ultimate Oxygen Demand (UOD).

This rapid rate of decay (almost 65% per day) can be explained by the presence of organics which are, relative to the organics in blackwater, more readily available to micro-organisms.[Fig. 3]

Blackwater, by contrast, contains, in addition to feces, cellulose from toilet paper and nitrogen compounds (e.g., urea) from urine requiring oxygen for nitrification. All these processesh happen relatively slowly in a water environment and the nitrification typically does not even start until the carbon stage of the decomposition comes near its end.

Comparative Rates of Decomposition in Greywater and Blackwater.

(greywater = bath, dish and wash water;   blackwater = water from flush toilets)

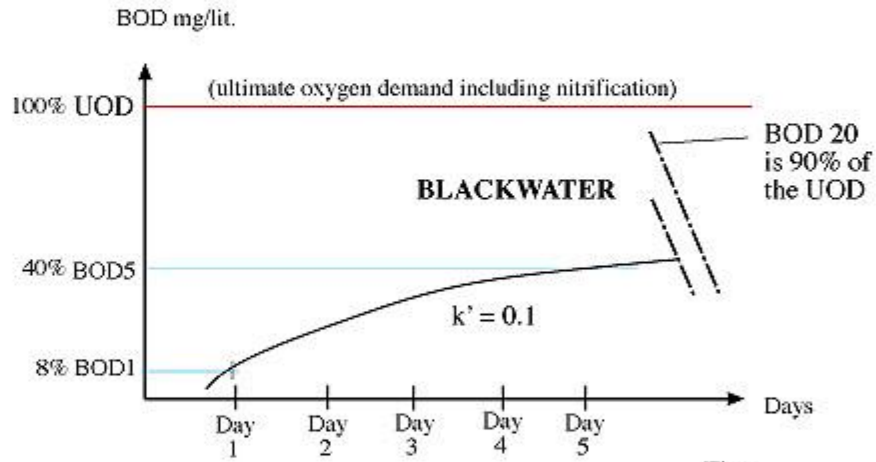


Fig. 1

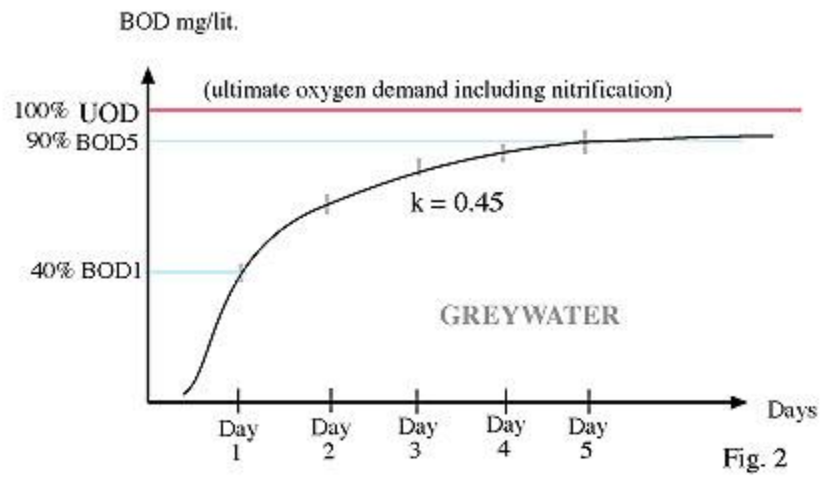
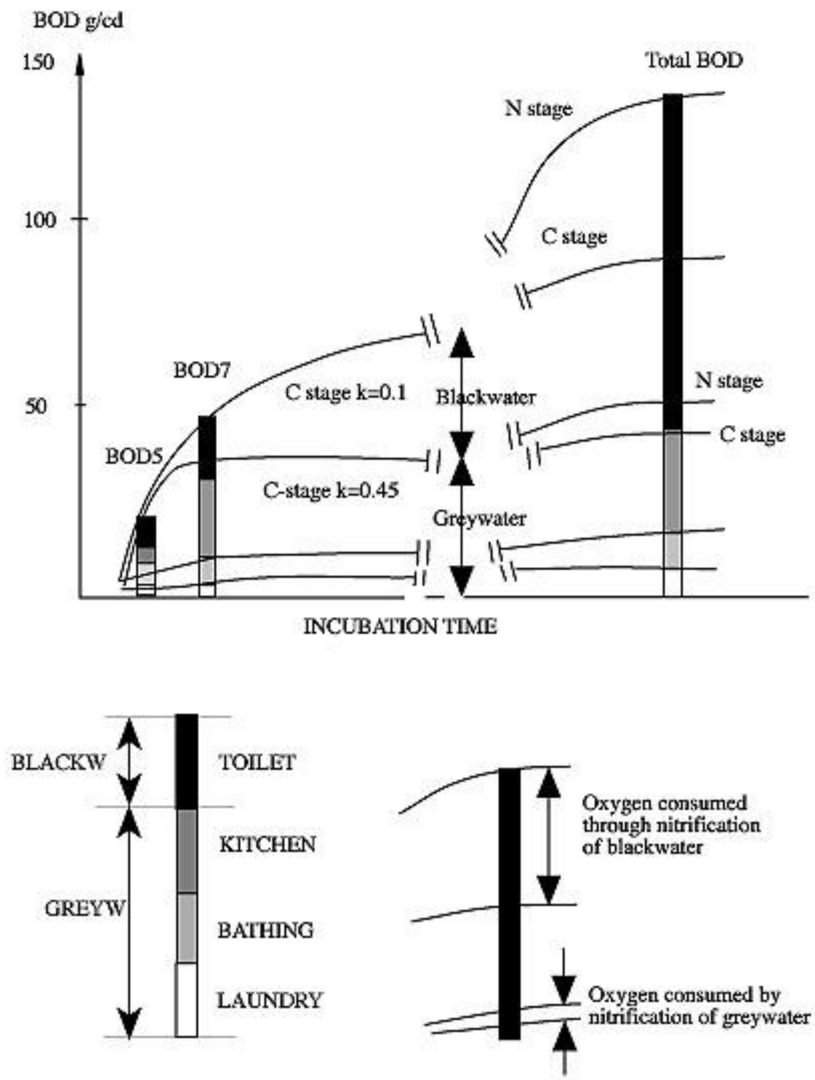


Fig. 2

Source: Olson E. et al. "Residential waste waters" - The Swedish National Institute of Building Research. 1967



From Residential Waste Water, Ahl, Karlgren, Olsson, Tullander. VATTEN 3 -67

Fig. 3

The significance of the differences in the rates of decomposition between grey- and blackwater are evident in terms of their relative impacts on ground water where treatment of blackwater and greywater is separated. Because of its rapid decomposition rate, greywater discharged into a stream or a lake will have a more immediate impact on the recipient body of water at the point of discharge than combined waste water. However, for the same reason, greywater will decompose faster in soils after infiltration and does not travel to pollute nearby drinkingwater nearly as much as do combined wastewater or blackwater discharge.

The safest and most effective way to prevent negative environmental impact from the by-products of our digestive systems is to keep them out of water altogether ---be it either surface or groundwater.

Confined, long-term (over-several-years), "natural" composting kills pathogens and transforms toilet wastes into odor-free fertilizers and a valuable soil conditioner. Confined, natural composting also keeps groundwater from being polluted by nitrates (sourced in urine to about 90%.)

Nitrite is one of the metabolic products when urine is oxidized through nitification.Nitrite is turned into nitrosamines in the stomach tract and is linked to cancer [non-Hodgkins lymphoma].

To maintain aerobic conditions, quick treatment is needed

Contrary to blackwater, greywater is not malodorous immediately after discharge. However, if it is collected in a tank, it will very quickly use up its oxygen (as explained on the previous pages) and will become anaerobic. Once it reaches the septic state, greywater forms sludge that either sinks or floats depending on its gas content and density. Septic greywater can be as foul-smelling as blackwaste and will also contain anaerobic bacteria, some of which can be human pathogens. Consequently, a key to successful greywater treatment lies in its immediate processing before it turns anaerobic.The simplest, most appropriate treatment technique consists of directly introducing freshly generated greywater into an active, live topsoil environment.

Figure 1 shows one time-tested greywater management approach which employs prefiltration to remove fibers and subsequent pressure infiltration using a piped distribution system that can be laid directly in the soil for plant irrigation. This treatment approach presupposes that the greywater does not contain any significant food waste and grease from kitchens.
Figure 2 shows a system which relies either on gravity or batch dosing of raw greywater into a shallow soil environment see Nutricycle.

The Classic Swedish Study

The figures in Table 1 are from the Tullander, Ahl, and Olsen report published in Sweden in 1967 and still highly valued for its representation of the relative pollutining chracteristics of the greywater and blackwater generated in a multi-storey apartment building in Stockholm whose plumbing separates grey and blackwater fixtures. The ultra-low flush toilet used in this investigation was a vacuum toilet using about one pint of water per flush. Sewage also contains pathogens capable of spreading disease. The great majority of these pathogenic organisms are derived from toilet waste which endanger the drinking water supply. (This issue will be addressed later with respect to greywater and the treatment method recommended to make it safe to recycle.) In the apartment building tested, there were several families with young children, accounting for a relatively high count of thermostable coliform 44º in the greywater, especially from the bathrooms and laundry. The risk of bacterial communication from the untreated greywater was estimated by the research team as low.

Table 1: Quantity and Relative Pollution in Greywater & Blackwater

Analysis	Greywater	Blackwater	Grey+Black	Greyw. %	Blackw. %
BOD5 g/p.d	25	20	45	56%	44 %
COD g/p.d	48	72	120	40 %	60 %
Total Phos.g/p.d	2.2	1.6	3.5	58 %	42 %
Kjeldahl N g/p.d	1.1	11	12.1	9 %	91 %
Total Residue g/p.d	77	53	130	58 %	41 %
Fixed Tot.Res. g/p.d	33	14	47	70 %	30 %
Volatile T.R. g/p.d	44	39	83	53 %	47 %
Nonfilterable g/p.d	18	20	48	38 %	62%
Fixed NonFilt.g/p.d	3	5	8	38 %	62 %
Volatile Nonfilterable g/p.d	15	25	40	38 %	62 %
Plate c 35ª	83x10e9	62x10e9	145x10e9	57	43
Coli 35º	8.5x10e9	4.8x10e9	13x10e9	64	36
Coli 44º	1.7x10e9	3.8x10e9	6x10e9	31	69
Effluent flow (litres)	121.5	8.5	130	93	7
g/pd=gram/person.day(24h)		Ultra low-flush vacuum toilet			

The relatively high numbers of general bacteria are probably related to the high bacterial growth rate in the plumbing system itself. The human pathogens do not, as a rule, find growing conditions hospitable outside the human body.

This as well as many other studies demonstrate conclusively that about 90% of all water-borne pollutant nitrogen comes from flushtoilets--largely from urine.

Later data suggest that the amount of phosphates in detergents has, in recent years, been lowered significantly.

Data Compiled from other Studies

American Biochemist Dr. Margaret Findley has made a valuable, comprehsnive survey of research focusing on greywater/blackwater separation. She found five well-researched studies (1,2,3,4,5) and compiled data delineating their average quantity and quality as shown in Table 2. Though there is some variation, the patterns indicated lead us to propose alternative and, in our opinion, a more rational greywater management/treatment approach than that offered by current conventional technology.

Average Pollutants Loading (grams per person per day - g/p.d)		
Type	Greywater	Grey + Black combined
BOD5	34	71
SS	18	70
Tot. N	1.6	13.2
Tot P	3.1	4.6
Tot P*	0.5	1.9
* No Phosphorous detergent		

Table 2.

What is the goal of treatment?

Earlier water protection efforts focused almost entirely on sewage treatment to reduce primary, secondary and bacterial pollution. In the 1960s and '70s, central sewering was considered *the* answer to reducing water pollution. This naive belief disregarded the fact that huge amounts of sludge are generated by the central collection and treatment of sewage. Moreover, sewage sludge is unusable, containing as it does, not merely some fertilzing components but everything which our civilization chooses to "get rid of"--including toxic substances causing cancer, birth defects and a variety of health problems that we have only started to see manifested by pollution. Infectious disease problems, for example, have doubled in the last 40 years largely due to the disasterous results of pollution on our immune systems.

Although it is not yet government policy to **safely** retrieve the fertilizing value of now wasted organics from households, Clivus Multrum engineers, design its treatment processes with safe nutrient retrieval as its goal. In that context, experience tells us that greywater and blackwater must be treated and retrieved on-site before they get mixed and ruined by non-organics of unknown character. On-site composting of toilet and food wastes is more likely to accomplish the goal of retrieving household-generated organics without chemical contamination. Long-term composting kills human disease organisms, making its end-products safe for recycling. (A rare exception is the organism causing tetanus---an organism, incidentally, which can be found in any top soil.)

Conventional on-site treatment means septic tanks and leachfields. Since their function (except when they "back-up") is not detectable at ground level, they have been assumed to be "working". But the notion of "working" needs redefinition.The basic problem with conventional septic systems is that they introduce nutrients and microbes too deeply into the ground for any natural processes of decomposition and plant uptake to happen. In nature, almost all organic material is processed on or very near the surface by numerous macro- and micro-organisms. And plant uptake is the last--and-crucial--stage in the recycling of these nutrients.

Conventions for leaching facilities specify that beds or trenches be dug 24 " deep and filled with 6" of gravel, with 4" distribution pipes laid on the gravel and covered by an additional 2" of gravel followed by 12" of soil. The minimum distance between the bottom of the trench/field and groundwater or an impervious stratum must be no less than 4' according to the National Manual of Septic Tank Practices(14). The size of the leaching area is determined by the percolation rate. "The perc rate" is the standard test which measures the rate at which water escapes from a hole dug to the proposed depth of the seepage system. This rate must generally be faster than one inch per hour (expressed as "60 min/inch"). Since there is generally less plant uptake or other biological utilization of nutrients possible from these deep systems, inevitable long-term pollution is associated with them. When grey wastewater is infiltrated into shallow beds, however, the reduction of BOD and bacteria has been shown to be nearly complete (20), and the environmental impact will be from the chloride, nitrate and sulfate salts primarily associated with blackwater.

New, alternative greywater treatment/management technology which is now emerging (15,16,17,18,19) addresses the issue of direct groundwater contamination as well as the indirect pollution of lakes and rivers from failing septic systems. Many jurisdictions are adopting this new approach and have started to accept a variety of alternative technologies, some of which we will now describe.

Summary repeat - Key differences between Grey- and Blackwater:

- **Greywater decomposes much faster than does blackwater**
  - therefore, if injected near the surface of a bio-active soil, groundwater is better protected from organic pollution, since the treatment takes place rapidly in the soil and is practically finished two - three feet below the surface.
  - this is also the reason for the popular misconception that greywater is "stronger" than blackwater - the total effect of the 'grey pollution' is smaller but it shows up right away...
- **Greywater contains only one-tenth of the nitrogen contained in blackwater**
  - nitrogen (as nitrite and nitrate) is the most serious (cancer causing) and difficult-to-remove pollutant affecting drinking water. Therefore, logically, the removal of blackwater from septic tanks should give a septic-system owner a 90% "nitrogen credit"...
  - Furthermore ,the nitrogen found in greywater is around half organic nitrogen (i.e.,tied to organic matter) and can be filtered out and used by plants).

PLANNING A NEW GREYWATER SYSTEM

There are two ways of planning your greywater system:

a) by assuming that the system is for you and your family's use (your actual situation);
b) or that the system is intended for the house regardless of who occupies it(i.e.,basing your calculations on the number of bedrooms the house has).

Steps to follow:

1. Take a brief inventory of the house's greywater sources and the number of uses that they get or could get.

Laundry		gal / person . day
Dishwasher		gal / person . day
Bath		gal / person . day
Other sources		gal / person . day
Total greywater		gal / person . day

Try to determine how many gals. per cycle your appliances use--or use the short-form sizing estimator below.

Approximate water use of standard appliances

US clotheswashing machine (top-loading)	30 gallons per cycle
European (front-loading) clotheswasher	10 gallons per cycle
Dishwasher	3 - 5 gallons per cycle
Low-flow shower head (per shower)	3 - 7 gallons per average use
Other sink use (shaving, handwashing, etc.)	1 - 5 gallons per average use

2. Use the General Site Data and Design Considerations below to determine what steps are relevant for your situation. Give special consideration to the final dispersion of the effluent, making sure that the soil can accept the amount of water that will be generated, treated and discharged (your local sanitation engineer can do a percolation test to determine the ability of the ground to accept water). If water shortage happens to be a particular restriction where you're located, note that greywater filtered through a soilbed of the sort described in this text will not become anaerobic and thus can be saved for [lawn] irrigation.

A. Overall Site Plan

- Topography
- Slope
- Soil Conditions
- Ledge
- Groundwater
- Buildings
- Utilities
- Property lines
- Vegetation
- Wetlands

B. Regulatory Requirements

- Plumbing Code
- State Regulations
- Reuse Regulations
- Effluent Discharge Limitations:
    - BOD
    - NO3
    - E-coli
    - other.
- Land Application Regulations
- Permit Question
    - Local Board of Health
    - State Environmental Regulations
    - Building Code Requirements
    - Monitoring Requirements
    - Test Data for Approvals

C. Design Information

- Existing Treatment Facilities
    - Septic Tank
    - Leach-field
    - Cesspool
    - Other
- Influent Quality and Quantity
    - Number of Bedrooms
    - Number of Persons regulary in residence
    - Occupancy (i.e.,on a year-round or seasonal basis)
- Type of Appliances and fittings
    - Flow-Rates:
    - Dishwashers
    - Washing machines
    - Bathtubs, showers
- Evaporation Rates
- Temperature Data
- Rainfall Data

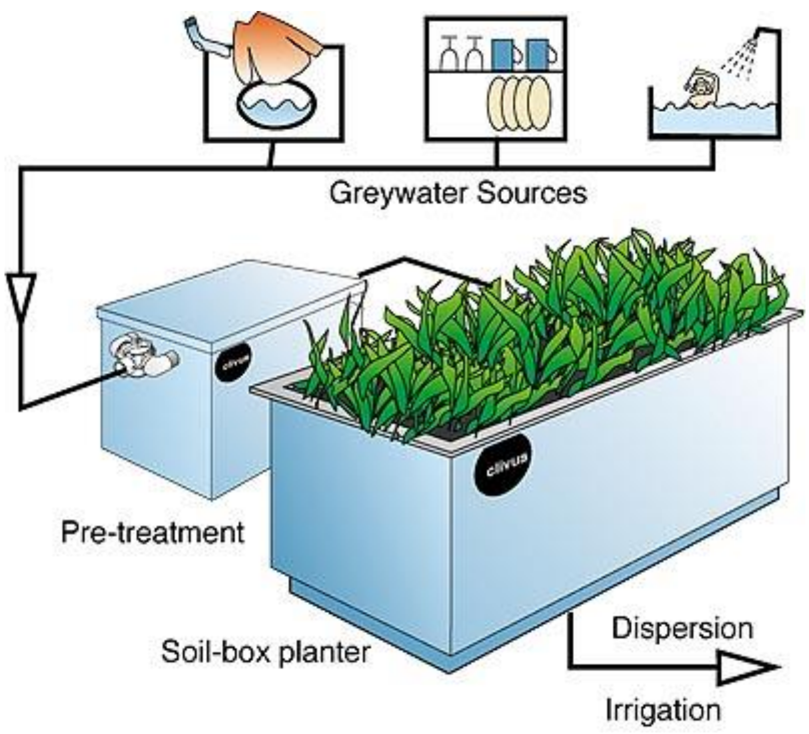
D. New System Specifications

- Propose Treatment Train
- Technical Specifications
- Effluent Treatment Character -Typical Transformation
- Reduction in Pollution
- Production of Fertilizer
- Reuse Opportunities
- Optimum Use of Existing Facilities
    - Existing Pipes
    - Dispersion Beds
    - New Use of Existing Equipment
- Potential for Savings
    - Water
    - Fees - Water and Sewage
- Overall Improvement Evaluation

• Effluent Reuse Goals	

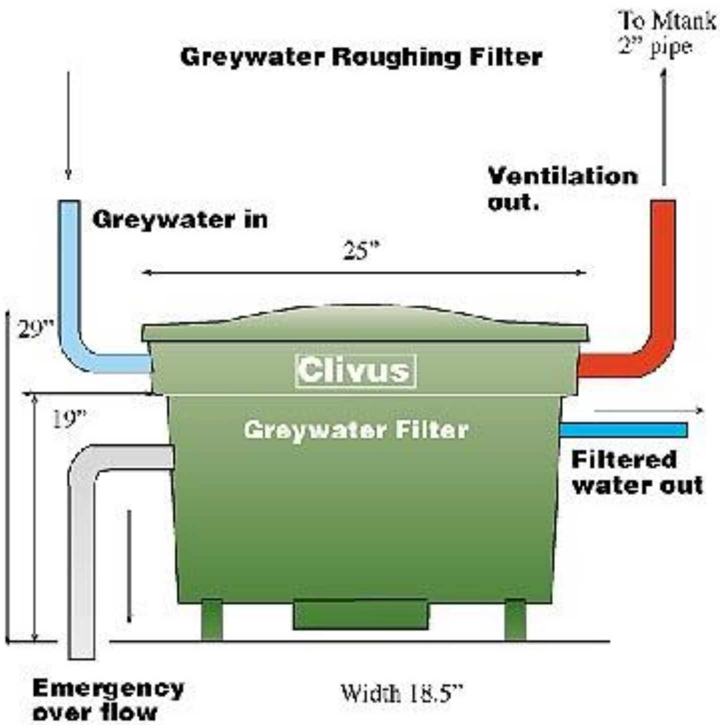
3. Check with your local authorities regarding any special/local concerns and regulations. Submit your application to the local board of health or consult your local professional engineer (P.E.) for plans and documents needed for your application (usually a topo-graphic site drawing with pertinent information about your site and the proposed solution). If your local P.E. is unfamiliar with alternative greywater pollution prevention systems (e.g., soilbed treatment), provide her/him with the name of this website or send a copy of this manual.

TREATMENT TECHNOLOGIES



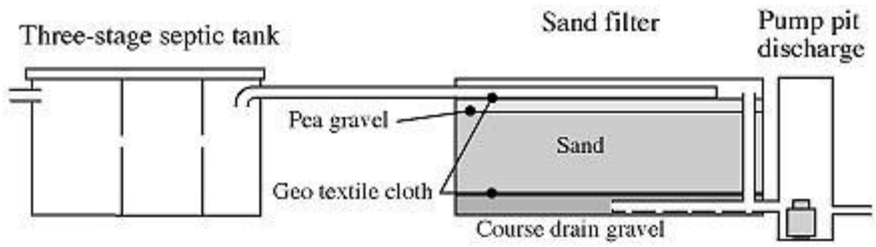
Aerobic Pre-treatment -- suitable for showers, hand-washing and laundry* water treatment.

The aim of this stretch filter treatment technque is simply the removal of large particles and fibers to protect the subsequent infiltration pipes from clogging and transferring it as soon as possible for treatment into a biologically active, aerobic soil-zone environment where both macro- and microorganisms can thrive. Stretch-filters are made to retain fibers and large particles and allow the rest of the organic material to travel on to the next stage of processing. This filter is suitable for public facilities where the principal source of greywater is hand-washing and showers without any food waste to speak of. If this type of filter is used to remove food wastes, these will accumulate in the filter which then becomes anaerobic and makes the effluent malodorous.The result is often that too frequent changes of the stretch-filter becomes necessary ---thus creating an undesirable,high-maintenance situation. See diagram below for a typical Clivus greywater management fabric filter configuration:



*Beware of the use of harsh detergents and bleach if the water is to used in or near gardens growing edible plants. Some surfactants are associated with controversial hormone-mimicking characteristics that we need to be aware of. We also need to be aware of handwashing soap containing antibacterial chemicals which are totally unnecessary and do not improve cleansing.

Anaerobic to aerobic pre-treatment
If any significant quantity of food waste enters the system from dishwashers and kitchen sinks receiving cooking grease and a fair amount of food residue, this option is recommended. A typical installation is not very different from a traditional system; but the treated effluent is of much better quality and does not pollute nearly as much. Ideally, it should consist of a three-stage septic tank for sludge and grease separation. The separated sludge can thus be removed less frequently [every fourth year instead of bi-yearly as is standard practice with many conventional systems]. The outgoing effluent in the septic system is anaerobic. Following the septic tank is a sandfilter designed for restoration of aerobic conditions. The final treatment stage leading to purified water of near potable-quality is treatment in a planter bed. This is not the most inexpensive solution. It is, however, one of the most effective,simple-to-maintain on-site treatment techniques available today.



Grease-trap/septic tank + sandfilter + sample/pump pit

Clockwise from top left:
1. Three-chamber septic tank
2. Sandfilter with a geo-textile cloth (courtesy of Civil Eng. Hans Lönn, Älgö Sweden)
3. Final result from the sandfilter (swimming-quality water)
4. Close-up of the effluent: odor-free, clear and suitable for planter irrigation.

Planter soilbox design

Soilboxes have been used for greywater purification since 1975 with excellent results. The planter bed has to be well drained to prevent the formation of a water-logged zone in any part of it. Therefore, its bottom contains a layer of polyethylene "actifill" or pea gravel to provide effective drainage. A layer of plastic mosquito-netting on top of the actifill prevents the next layer of coarse sand from falling through. On top of the coarse sand is a layer of ordinary concrete-mix sand, while the top two feet consist of humus-rich top soil. Clay soils must not be used.

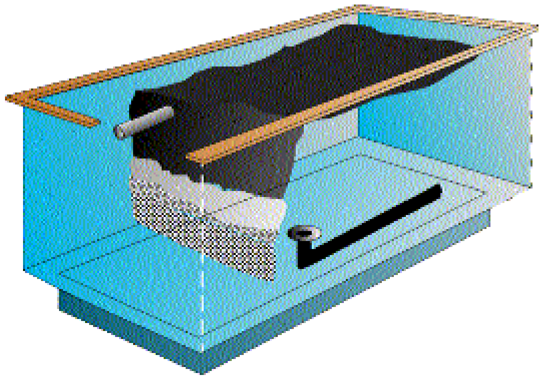


Figure 1a

Water injection without erosion

The pressure infiltration pipes are designed to allow for even distribution of the water even on uneven terrain. They are easy to clean and should be placed on the soil surface after planting and then covered with a 2 to 4-inch-thick layer of wood chip mulch. In cold climates the change from shallow infiltration to a deeper layer can be accomplished by an automatic switch-over (as described below in Fig. 9). The pressure infiltration piping (shown above) consists of two concentric pipes, the inner one having holes pointing up and the outer sleeve fitting snugly over the inner pipe and somewhat expanded by the water pressure when ON. This causes the water to" bleed" out along the slot at the bottom. Water pressure OFF makes the sleeve close, preventing worms, insects and roots from entering the pipe and clogging it from the inside. Piping is available in 5-ft sections and can easily be coupled together through a quick-connect system. These pipes are easily cleaned without disassembly.

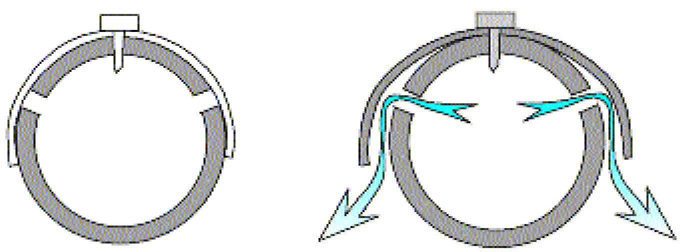


Figure 1b

Gravity or pressure leaching chamber

Hanson Associates of Jefferson, Md., reports that leaching chambers have operated successfully at a loading of 2.4 gal/sq. ft. per day receiving all the greywater from a three-bedroom house. Using half a PVC pipe 6" diameter according to the figure below, this leaching chamber can be placed in a trench on a 1-2 inch mesh plastic netting (to prevent the walls from sinking into the soil). No pre-filtration is used--only a dosing pump chamber pumping every 8 hours.

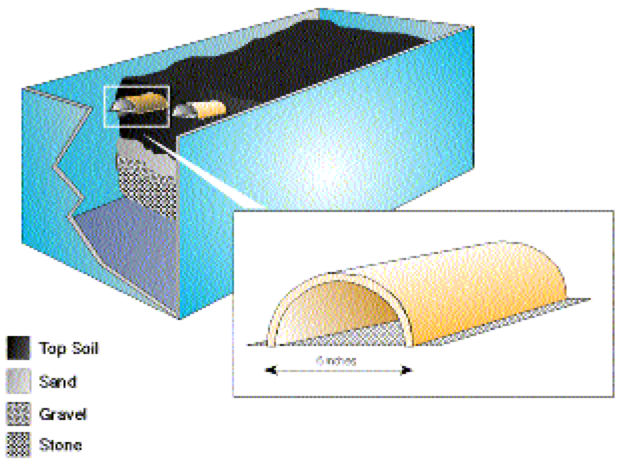


Figure 2

Sizing for a residence

3 bedrooms @ 150 gal/b.r. = 450 gal/day. Subtract 50% for no-flush toilets and reduced-flow shower heads etc. = 225 gal/day. The minimum trench surface area is therefore around 100 sq ft using a loading rate of around 2-2.5 gal/sq. ft/day

Specify:

5-20 feet long and 1 foot wide trenches.

Flooding dose:

100 sq. ft x 1" desired water depth = 62 gal per dosing

Dosing chamber can be a Clivus LPF pre-treatment filter container without the stretch filter.

Gravity switch from shallow to frost-free zones/levels

Figure 3 shows an example of automatic switching from the shallow leach chamber to one which is below the frost line. If the shallow trench freezes and becomes clogged with ice, the water will back up and spill over into the pipe for the deeper trench. It should be noted that greywater is warmer than combined sewage and that, therefore, shallow leach zones in operation tend to stay free of ice much longer than is normally expected of combined waste waters. One notes a warming of the soil and biological activity which make freezing rare even in fairly cold climates.

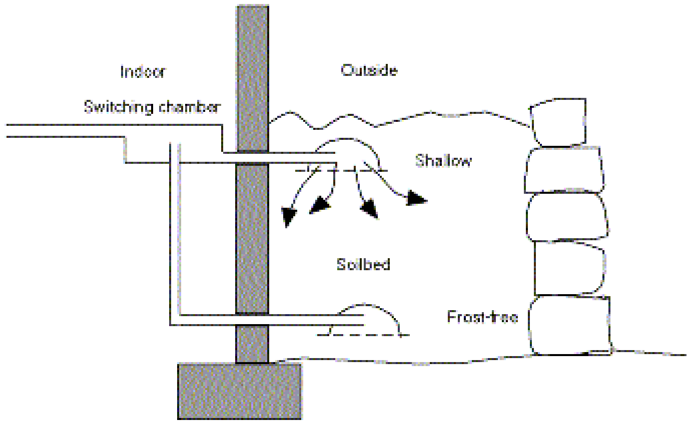


Fig. 3

Automatic switching of levels using pump pressure is somewhat different from gravity pressure. In this case, a loop has to be arranged indoors where the pressure needed for the shallow infiltration normally is lower than the pressure required to force the water up to the top of the loop. The top of this loop must, of course, not exceed the shut-off head of the pump. A margin of around three feet of water is desirable. Figure 4

The system can equally be designed to be switched manually by the opening and closing of the valves feeding the different zones/levels.

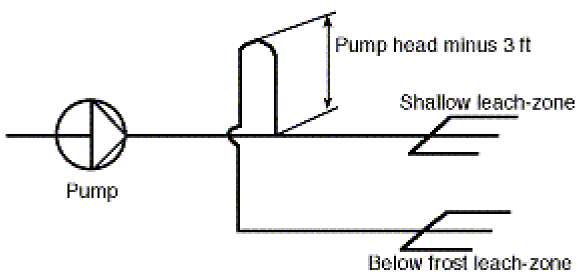


Fig. 4

Other Cold Weather Options

There are several greywater-irrigated greenhouses located in New England. Some of these have been in operation since the 1970's and feature a combination of automatically irrigated and fertilized growing beds which provide effective greywater treatment. One 12 ft x 36 ft greenhouse near Concord, NH uses as the final treatment--after the soil beds--a fish pool, which stays clear by means of a biological treatment technique involving a waterfall and bio-filter plates on the pool-bottom(21). Deep soil beds tend to store heat both from the sun and from the greywater itself. The New Hampshire greywater-irrigated greenhouse is the top cold climate producer of salad greens in the US according to a survey carried out by A. Shapiro at the National Center for Alternative Technology (22).

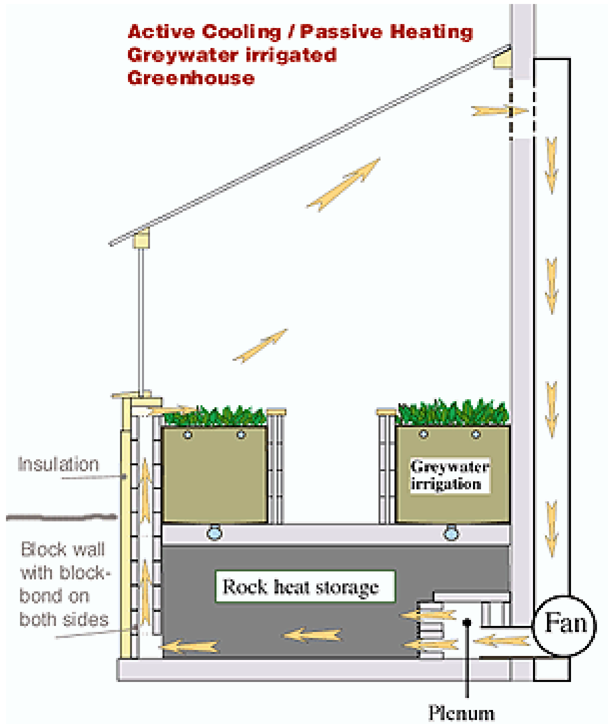


Figure 5

This greenhouse provides a family of 4 - 6 people with more than enough salad greens throughout the long New England winter. Winter vegetables grown in it include broccoli, spinach, lettuce, mustard greens and sorrel (see below) (15).

Another simple way to facilitate better distribution of the greywater in the soilbed is to make a pipe-loop that is fed from both sides -- see the sketch below:

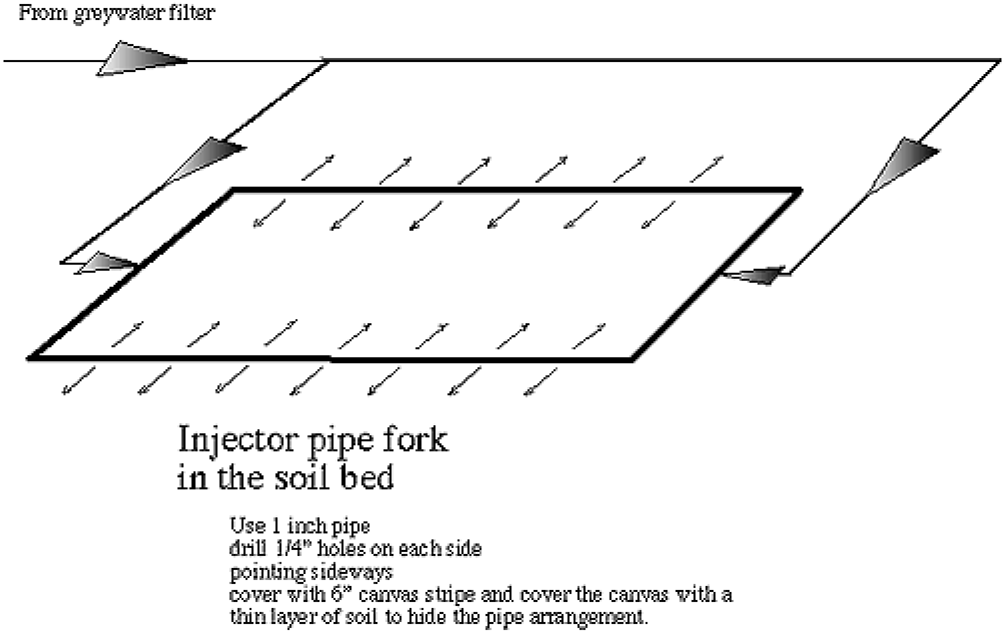


Figure 6

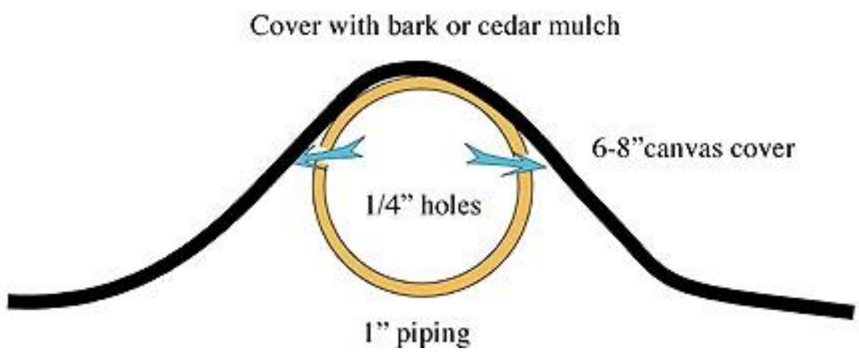


Figure 7

Out-door planters

There are several variations on the theme of outdoor raised soilbeds that effectively replace the soil needed for an effective leach field treatment of waste water. Houses on ledges or very sandy soils that would not effectively slow down effluent sufficiently to accomplish treatment can be fitted with masonry soilboxes which, in effect, serve to build up the site's soil profile. This strategy has been used in so- called mounds or Evapo-Transpiration beds (the name derived from the often erroneous assumption that all the water will evaporate to the atmosphere even in wet and cold climates).

Photo: Laurence Scott©

Joan van der Goes residence, Vancouver Island, B.C.: greywater planter at the start of the growing season

The vegetable and ornamentals-filled greywater infiltration bed at the end of summer season

Photo: Laurence Scott©

Laying the greywater irrigation pipes

Joan van der Goes and her Clivus Multrum composting toilet

In areas where the density of construction makes it difficult or impossible to build up a large mound or to locate planters on the property for treating the volume of effluent produced, two adjacent neighbors can agree to build property dividers and plant hedges or evergreens as their leaching area. This space-saving alternative combines privacy and aesthetics with good environmental protection. Greywater gardens as depicted above can offer the added benefit of one's being able to garden at a back-saving height...

In colder climates, treatment will be less effective during the winter season, and at times there may even be trouble as a result of freezing. However, this is often less of a technical problem than it may seem to be at first glance:

-When relatively warm greywater is injected into the soil, increased biological activity as well as a warming of the soil tend to keep the injection zone unfrozen longer than surrounding areas.

-In rural or suburban locales, raised beds/planters may often be ideal for use as leaf "compost bins" in the fall. The leaves act as an insulator as well as a composting fuel-source that further insures that the soil underneath does not deep-freeze.

Shallow subsoil (i.e., at 2-6 inches below soil-level) irrigation is preferable to surface irrigation

- whenever the water used is "grey"(i.e. neither clean nor free of salts which leave saline deposits when applied on the soil surface);
- when located in a high evaporation locale suffering from water shortage;
- when one wants to produce leaf or garden waste compost fast and create and maintain an earthworm community in one's compost-pile;
- for selective irrigation (a flower border, a shrub, a bush or a tree);
- when you want to automatically irrigate a drained planter either indoors or outdoors.

Sample soil beds for greywater irrigation and infiltration

Mass Audobon, Wellfleet Cape Cod
Mass Audobon Society bird sanctuary in Wellfeet, Cape Cod in Massachusetts. The building had a requirement for no-discharge and is equipped with composting toilets and greywater planterbeds that thrive in the light from the sky-lights and large windows in the greenhouse like corridor.

Little Compton Rhode Island
Small outdoor planterbed serving Little Compton's library in Little Compton Rhode Island. 2 sinks and a janitorial sink delivers the water for a 3 x 8 ft planter bed.

Prefilter for the handwash water used for irrigation in a small bed outside.

Wampanoag Tribes Bld, Martha's Vineyard, greywater is cleaned and the plants are fed and watered in one process.

There is actually just barely enough water to go around all the planter beds.

Private Residences, New England

This lean-to greehouse in New

Since soil beds can operate odorlessly, they can be sited in both natural light or under grow lights. They can be placed in a south-facing

Hampshire is actively cooled during the day and in the night the heat under the floor rises up and prevents freezing during the dark and over-cast

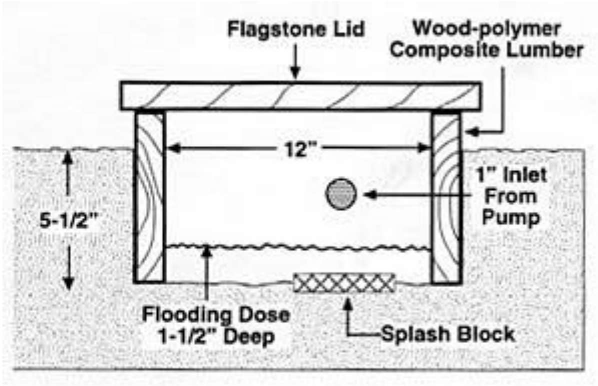
window, they can be sunk into the floor as was done in a model home in Cambridge, Mass.

Private Residence, Cambridge, MA

This planterbed was originally built to demonstrate greywater use in a masonary soilbed on the floor of a basement living room.

Lewis Mill, Md. Hanson Bros.
Pioneers in gravity operated greywater treatment systems. These outdoor planter beds have successfully been used for greywater irrigation and infiltration devices for well over a decade.

These systems should be planned as part of the lanscaping of the site. Attention needs to be given to the strata underneith so that water can drain away after infiltration.



Hanson Bros. Cont.
This greywater trench is set up for dosing/flooding with around 1-2" of greywater per cycle. Can be utilized both as gravity and pump operated systems.

Showing a flower bed installation with trenches covered with flagstones that doubles as walk ways. See their site http://www.nutricyclesystems.com/

Peggy's Cove in Nova Scotia, Canada
this leachfield vegetable garden serves a high use public facility operated by Tourism Nova Scotia. The greywater from the handwashing lavs is pre-treated and then injected just under the garden's soil surface.

Cedar, British Columbia, Canada: the van der Goes residence

Out-door soil beds can be used as property dividers (for a hedge); as landscape-enhancing planters at the entrances to commercial buildings. With the latest lighting technology, vegetables can even be grown in completely dark rooms or basements

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Leslie Science Center, Ann Arbor, MI
Administered by the City's Department of Parks & Recreation. Also equipped with two composting toilet systems largely used by children involved in the Center's eco-education projects.

Greywater irrigated south-facing planter bed in the Leslie Science Center 's MichCon Nature House works as the greywater purification plant.

Planter beds of different shapes and denominations have been used for symbiotic irrigation and treatment in many public facilities around the USA and Canada

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Indiana County, Pennsylvania lakeside meeting center. Flower beds are an ideal use of the greywater irrigation and purification planters.

Greywater irrigated lean-to greenhouse where overcast skies are rather the rule during the winter.

LINKS

The Environmental Directory

For Treatment and source separation of nutrients in toilet waste, visit
http://www.clivusmultrum.com

For other practical gardening and landscaping greywater designs visit
http://www.oasisdesign.net

For Nutrient recycling and low-maintenance gravity greywater treatment systems
http://www.nutricyclesystems.com/

NutriCycle Systems LLC
sustainable alternatives to septic systems and sewers

Linking Health and the Environment Through Better Technologies http://www.riles.org

ReSource
INSTITUTE FOR LOW ENTROPY SYSTEMS

HOME	Synposis	Planning	Pollution	Treatment	Samples	Links	References

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The Water Conservation Alliance of Southern Arizona is the collaborative voice of Tucson area water providers. Our goal is to enhance the public's awareness and understanding of water conservation issues, methods and practices. http://www.watercasa.org

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T. R. Strong Building Systems, Inc. is a Manufacutrers Representative and supplier of green building materials to the commercial and residential construction markets.http://www.baubuilder.com

tom_st_louis@msn.com

Listing for a magnitude of environmental information.
http://www.envirotech-list.com/

KwMap.com - browse the Keyword Map of Greywater.com

L3xicon.com - a web thesaurus and lexicon listing Greywater.com under grey water, waste water and irrigation

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Link to Environmental-friendly Products
Enviro-Friendly Products supply greywater, rainwater harvesting and solar hot water systems, water tanks, leafless guttering and AAA showerheads.

Enviro-Friendly Products

http://www.enviro-friendly.com/default.shtml

Rain Barrel -- collection of rain water

Rain Barrel Guide
Instructions on determining how much water you use, how much you can collect from rain runoff, and clear instructions on setting up your own system.

http://www.rainbarrelguide.com/

Organic Pest Control

Learn to identify and control garden pests organically, along with general organic gardening strategies.

http://www.organicgardenpests.com/

CHELSEA GREEN
PUBLISHING

Excellent publishing site covering green technology and thinking.

http://www.chelseagreen.com/

Organic Rose Gardening

Tips, tricks and advice on rose gardening the organic way

> "The secret to successful organic gardening of any kind
> is to understand the way nature works."

http://www.organicrosegardening.com/

MAC Pharma Network

A unique online health resource with information on hundreds of diseases and drugs along with a popular offshore based internet pharmacy.

http://www.mac-pharma-network.com

Rainwater Harvesting Systems

http://www.rain-barrel.net/

America's Favorite Hot Tub Supply
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Spa Depot offers a wide range of hot/hut tubs, spas and hot tub accessories at great prices, with thousands of accessories and products to fit your needs.

http://www.spadepot.com/

HarvestH2O.com

the online rainwater harvesting community

We work collaboratively with vendors, universities, research organizations, and most importantly, individuals across the globe to devise solutions for managing real world problems in water conservation. HarvestH20 is an independently managed organization.

http://www.harvesth2o.com/

Environmental House Plan

This site features an architect-created green house plan that was designed from the ground up to be energy efficient and environmentally friendly.
The inspiration for the plan came from a growing awareness that new houses were getting bigger and bigger but with little redeeming design merit. The problem is that comfort has almost nothing to do with how big a space is. It is attained, rather, by tailoring our houses to fit the way we really live, and to the scale and proportions of our human form.

http://www.ecohouseplan.com/

DirectoryScience

The comprehensive science directory

DirectoryScience.com - The Comprehensive Science Directory. The online Science directory designed to help its users find the online science source, companies, products, services, and information.

http://www.directoryscience.com/

Water Health and Conservation

Information on water health and conservation, including articles and news about the earth's water supply.

Eco Earth - The Environmental Sustainability Source
An Information Gateway Empowering the Movement for Environmental Sustainability
The Eco-Portal is now Eco Earth with a new shorter URL of http://www.EcoEarth.Info/

http://www.ecoearth.info/

Learn to grow your own delicious sweet corn, organically!
Tips and information on growing corn without pesticides or harmful chemicals.

Title: Sweet Corn Gardening Tips
http://www.sweetcorngrowingtips.com

Description: Lettuce Growing Tips is a complete guide to growing lettuce for the home gardener with an emphasis on natural and organic gardening techniques

Lettuce Growing Tips
http://www.lettucegrowingtips.com

Description: Cucumber Growing Tips is a complete guide to growing cucumbers for the home gardener with an emphasis on natural and organic gardening techniques.

Cucumber Growing Tips
http://www.cucumbergrowingtips.com

A complete guide to growing carrots in the home garden. We emphasize natural and organic growing techniques for your carrots.

Carrot Gardening Tips
http://www.carrotgardeningtips.com

Garden in small spaces by gardening vertically! We also show you how to use garden arbors, trellises, and other vertical gardening structures. Learn about climbing roses, vines, and more!

Vertical Gardening Guide
http://www.verticalgardeningtips.com/index.html

You don't have to be a fanatic to go organic! A practical guide to organic gardening that doesn't make you feel bad for not going 100% organic. With tips on compost, advice on organic gardening products, and more!

Mostly Organic Gardening
http://www.mostlyorganicgarden.com/

Learn how to care for your yard and garden during the fall and winter. Our site focuses on natural methods to care for your garden during the colder months.

Fall and Winter Gardening Tips
http://www.wintergardeningtips.com/

GARDEN ARBOR STORE

At the Garden Arbor Store, you'll find a huge selection of garden arbors and trellises for your home. You'll find high quality iron, cedar, steal arbors, and much more!

Garden Arbors at the Garden Arbor Store
http://www.gardenarborstore.com

ECOLOGICAL INTERNET

Rain Forest Portal

Search, Inform, Debate, Act
http://www.rainforestportal.org

At Sussex Conservatories we are widely recognised as one of the country's leading conservatory suppliers. We offer a local service with secure guarantees at realistic prices for conservatory, conservatories, sunrooms, greenhouse, green house, climate, control, system, systems, sun, UV, rays, design, designers.

http://www.sussexconservatories.com/products.htm#windows

Replacement Windows Double Glazing, Anglian UPVC Windows
Anglian Windows, leading supplier of replacement windows, replacement doors, garage doors, driveways, conservatories, kitchens, roof cladding and garage conversions

http://www.anglianwindow.co.uk/

Introducing the AQUSTM from WaterSaver Technologies

WaterSaver Technologies produces the AQUS™ System, a water conservation system that captures greywater from bathroom sinks and recycles it for toilet flushing. Captured water is filtered and disinfected, then deposited in toilet reservoirs for reuse.

http://www.watersavertech.com/

Waterwise Systems, a company that provides water storage and grey water recycling solutions for Eastern Australia

http://www.waterwisesystems.com

If you want your lawn to be managed year round by experts you need to call the professional lawn care MA people at this site. MA residents know that the folks on this site know all about professional landscaping and maintenance. If you need lawn care MA, call the experts that Massachusetts residents trust.

http://www.noonturfcare.com/

SavingCivilization.org
Podcasts and commentary on things we can all do to help out the environment and save money while doing it!

http://www.savingcivilization.org

Enclosed Long-term Composting

http://www.compostera.com

Get to know the process of Enclosed Long Term Composting

http://www.compostera.org

The Greenhouse Catalog is your year round gardening source for greenhouse kits, supplies, accessories, and helpful greenhouse garden tips

http://www.greenhousecatalog.com/greenhouses-c-61.html

DirectoryGarden.com - Online Garden Web Directory including websites related to Garden Accessories, Garden Furnitures, Garden Tools, Gardening Support, Hydroponics, Intensive Planting, Landscaping, Plants and Trees, Soil and Additives, and more.

http://www.directorygarden.com

StoutKart is a small company dedicated to helping others get into business for themselves. Our products help people develop their own service offerings, while lowering the costs associated with hired help and reducing the chance of back injury.

http://www.stoutkart.com/

THE COVER STORE
Home of CoverMates™ Outdoor Patio Furniture Covers

http://www.the-cover-store.com/outdoor_furniture_covers.aspx

WGS INTERNATIONAL
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http://www.wgsi.com

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http://www.bracsystems.com

A rain barrel is connected to a downspout tube from a house or building. We make rain barrels that collect, store and divert rooftop runoff during a rain shower. Rain Barrel, Irrigation System & More!

Aaron's Rain Barrels

http://www.ne-design.net/

UK Manufacturers of Garden Offices & Garden Studios -Green Retreats The UK's leading manufacturers of high quality garden offices & garden studios. Our garden offices & studios can be used in a variety of ways but they are mainly used as garden offices and garden studios. Fully fitted, High quality, low prices guaranteed.

http://www.greenretreats.co.uk/

Water systems for drinking water, online source for ro and water distiller devices of most major brands

http://www.water-filters-purifiers-softeners.com

Bonnie Westwood Active Rain RE Blog

http://activerain.com/bonnierae

EcoEarth.Info
Environment Portal & Search Engine Empowering the Environmental Sustainability MovementEcoEarth.Info is a one of a kind Environment Portal - with genuine Internet search, cutting biocentric commentary, social network & constant news and link tracking

http://www.ecoearth.info/

Snapdragon -- innovative home & garden supplies

http://www.snappdragon.com/

Ecotist is on the UK Sustainable Development Commission 2007 > the Government's independent watchdog on sustainable development

http://www.ecotist.com

Indoor wall water fountains can add a very organic and natural feeling to your home or office. The natural sounds of trickling water down a water wall can create a soothing habitat to live or work in.

http://www.earthinspiredproducts.com/

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http://www.vernonmorris.co.uk/

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http://www.turtletanks.com/

Online Stormwater Training
Description = Stormwater USA is dedicatedly helping industry professionals for provides the Online Stormwater Training to the construction industry.

http://www.stormwaterusa.com/

Elegant rain barrels which provide water conservation and modern home and garden décor

http://www.gardensupermart.com/store/rain-barrels.php

General Environmental Science...
Biological Wastewater Treatment & Industrial Wastewater Treatment Solutions

http://www.generalenvironmentalscience.com/