Final Report

Using Laundry Water for Irrigation

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Prepared for Development Workshop
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Appendices

1.0 Problem Identification

1.1 Description

Development Workshop staff are currently active in community water supply, appropriate technology and small enterprise development projects in an informal, poorly serviced settlement surrounding Luanda, Angola. High population densities and scarce supplies of safe water are contributing to the spread of disease. Most of the settlement's population has access to only five litres of water per day per capita; this represents 25% of the World Health Organization's recommended consumption. Therefore, water reuse represents an important strategy for maximizing the management of this scarce resource.

One project proposed by residents is a community laundry facility, to be run by a local women's organization. The possibility for reusing the wash water to irrigate fruit trees or gardens exists. The laundry is not yet operating, nor has it been designed. Therefore, water volumes and quality are not known at this time. A preference for irrigating papaya trees has been expressed.

An examination of the feasibility of implementing this water reuse project, as indicated by relevant case studies and a literature review, is the aim of the current document.

1.2 The Angolan Context

Local climatic conditions are tropical but dry. The relative humidity is usually above 80%, and there is a distinct rainy season for five to six months of the year; between October and April. Total rainfall averages 350-400 mm/yr. The average daily temperature is 25-26° C. The bairros of Luanda, where the settlement is located, have an elevation of 150-170 m above sea level.

Angolan soils fall into two distinct categories (Serrano and Carter, 1991). Since Luanda is on a coastal river delta, the assumption may be made that its soil falls into the river valley bottom category, which is more suitable for irrigation. More specifically, the soils in the area are red and sandy "musseques" with a dark but shallow sandy and coarse superficial horizon and medium coarse texture subsequently. They have very little structure and poor nutrient content, possibly indicating a low organic content. The clay fraction is 10-20%, placing the soil classification anywhere from loam to sandy loam. The low clay fraction indicates that soil clogging by the application of water (possibly containing solids and nutrients) may not be much of a problem. The clay is predominantly kaolinite.

The soil also contains iron oxides, which give it the characteristic red colour. These oxides, the products of extensive mineral weathering, may indicate that the soil experiences waterlogging during part of the year. If this is the case, the soil would be unsuitable for septic tank construction. Iron oxides as hydrous oxides (goethite, hematite) are classed as clays, but do not have negative surface charges so will not hold adsorbed cations (sodium, potassium,...)[1].

Workers on site have indicated that the soils are well suited to growing tropical fruit trees.

[1] Hausenbuiller, R.L. (1985) Soil science : principles and practices, 3rd ed. Dubuque, Iowa : Wm. C. Brown.

2.0 Observations on the Literature

Investigations into household re-use of domestic wastewater centre around "greywater", which is inconsistently defined and spelled. Most often, greywater includes all water produced in the home, excluding toilet wastes. Shower, bath, sink (including kitchen sink) and laundry water are greywater candidates. Since the research has chiefly been carried out in the North American and European contexts, the use of laundry machines predominates. This presents the additional complications of higher temperature laundry water and more extensive use of laundry products (special detergents, bleaches or "whiteners") that make extrapolation of the data to the Angolan context difficult.

Several studies tabulate greywater quality parameters. (Anderson et al 1981, Novotny 1990, Rose et al 1991, Siegrist 1987). It is difficult to associate the contribution of laundry activities with these measured levels.

A number of systems to collect, treat and store greywater are identified (Ahlgren 1981, Anderson et al 1981, Farwell 1990, Foster and Karpiscak 1990, Ingham and Kleine 1982, Karpiscak et al 1991, Lombardo 1982, Novotny 1990, Prillwitz and Farwell 1994, Rockefeller and Lindstrom 1977, Rose et al 1991, Venhuizen 1990). Generally, some treatment is recommended before greywater reuse, especially when irrigating edible crops. The immediate use of the water for irrigation applications is sometimes recommended over the storage option. (Farwell 1990, Rose et al 1991). This is in order to avoid odour, propagation of disease agents, insect attraction and the general deterioration of water quality.

3.0 Assessment of Technical Feasibility

Generally, irrigating fruit trees with laundry water seems to be technically feasible. Major design decisions will include whether to treat and/or store the water before its application. Having a storage facility suggests that irrigation and laundry activities would not have to be paired. However, the intention of system users may to simply take buckets of soapy water and pour it around the trees. In any case, health risks posed by disease carriers contained in the used water and the clogging of soil by soapy residue and solid materials will be of concern. As well, possible overwatering and erosion resulting from vigorous surface application should be considered.

The wash water may provide nutrient phosphorus, potassium and calcium (from soaps) and nitrogen (from laundering diapers, etc.) to help trees, but could also contain excess amounts of these, plus sodium (from soaps), substances increasing biological oxygen demand and vectors of disease.

The quantities of water should be determined even roughly and compared with the papaya's evapotranspirational requirements.

Soil tests performed during the establishment of the system should be considered. The selection of either new trees or transplanted older ones will affect orchard requirements and may necessitate alterations in the irrigation system over time. The availability of workers to monitor, operate and maintain the system may be an issue.

4.0 Other Considerations

4.1 Bacteria and Health Concerns

Bacteria and viruses from diapers or sickness should not come into direct contact with the fruits under irrigation. Since wastewater (including sewage) is used for irrigation in many countries, I don't think that this is insurmountable. References to studies done on water quality of laundry and other greywater and the persistence of disease causing micro-organisms in the soil have been included. While the research indicates that greywater can have a significant coliform content, the major sources of these bacteria seem to be bath and shower waters (Rose et al, 1991).

4.2 Papaya Requirements

The evapotranspirational requirements of papaya trees would need to be determined, to see if they could be met by the laundry water alone. This information has not been ascertained, and it may be specific to the climatic conditions, papaya variety and stage of tree growth. The laundry water would need testing to determine solids, nutrient (nitrogen, phosphorus, etc.), salt and microbial levels. Soil may need to be leached periodically if the water's salt content is high. If the soapy water changes soil pH (alkaline detergents) or structure, the effect of this on papaya health is of concern. Soil amendments can be used to counteract pH changes. If subsurface water application is used, tree rooting depth should be determined.

While beyond the scope of the current investigation, the impact of a new orchard on the local environment (insect attraction, shade provision,...) could be of interest.

5.0 Case Studies

No specific examples of using hand laundry water for irrigation were identified. One article (Ahlgren, 1989) described the recovery of machine laundry water in a resort hotel, but the final destination for the water was not specified. The use of grey water has been studied, in terms of water quality, health risks, pre-treatment requirements, the volumes produced in a household context and the recovered water's suitability for landscape and garden irrigation. Most studies originate in arid regions of the United States; chiefly California and Arizona. The <u>Graywater Guide</u> by Prillwitz and Farwell (1994) seems very useful in that a small (individual household) system is described, and recommendations are made about suitable plants, detergent types, and design suggestions for subsurface irrigation and mini-leachfield systems.

5.1 California

A lot of work has been done here, as indicated by the attached documents and bibliography. (Ingham and Kleine 1982, Kourik 1990, Prillwitz and Farwell, 1994). Interest in using or reclaiming greywater seemed to increase greatly during the 1977 drought. Californians are using graywater for irrigation, including water from laundry activities, but greywater definition (Prillwitz and Farwell, 1994) excludes wash water from soiled diapers. Pretreatment and application methods are outlined. Greywater standards now form part of the State Plumbing Code.

The standards adopted in California may be overly stringent for Angola, in that achieving the high standards may well render water reuse schemes uneconomical. Health risks posed by coming into contact with the greywater, which is the rationale behind preferring subsurface application, loses some meaning when hand laundry procedures are being used.

5.2 Arizona

Research and demonstration activities at Casa del Agua are described by Karpiscak et al (1991) and Foster and Karpiscak (1990). This single family dwelling has been used to test various greywater recovery and treatment systems. Currently, the system includes a plastic drum used as a sump surge tank, a pump to direct water to two settling tanks, a slow sand filter planted with vegetables, and finally a storage tank from where the water is pumped to an irrigation system. Subsurface drip irrigation is used to support arid-adapted species.

5.3 Sweden

Evans (1993) briefly describes greywater reuse in three "eco-villages" in Sweden. Collection of household greywater from sinks, baths and showers, sand bed filtration and cistern storage precedes the water's re-use in irrigating landscaping or greenhouse plants. No specific mention is made of laundry water being included or excluded.

6.0 Annotated Bibliography

Ahlgren, Richard M. (1989) Potential for water reuse in conjunction with desalination systems **Desalination** vol. 75, p. 315-328

The article includes a description of the categories of contaminants present in wastewater (suspended solids, dissolved solids and trace materials including micro-organisms) and technical methods available to reduce their levels. The information is presented in tables. The most relevant part of the article is a description of a small dissolved air flotation system used by a resort hotel to recover laundry water. The final use for the water is not mentioned, nor is the reduction in pollutants quantified. The main objective of the users was to recover expensively desalinated water. The system includes chemical addition for precipitation, aeration, dissolved air flotation, sand filtration, carbon filtration and a final disinfection with ozone.

Anderson, Damann L., Robert L. Siegrist and William C. Boyle (1981) Performance evaluation of greywater recycle systems In : **Water Reuse Symposium II** : proceedings vol. 1, p. 65-82

A system that reuses home greywater (non-toilet wastes) for lawn irrigation was evaluated. The "Aquasaver" home system was tested in two homes over 647 days. The system employs initial coarse screening, sedimentation/storage, chlorine disinfection and pressure cartridge filtration. System performance, user acceptance and water quality were all monitored. Raw greywater was found to contain "appreciable quantities of oxygen-demanding substances, suspended solids, nutrients and fecal organisms". The authors found that the system did not completely remove pollutants : in fact, the levels increased at one of the homes, possibly during greywater storage. The pressure cartridge filter made a minimal contribution to water renewal. Water quality was marginal (in terms of BOD_5, dissolved and suspended solids and coliforms) for lawn irrigation.

High chlorine residuals could also be a problem. The authors concluded that reuse was technically feasible, with water disinfection and system maintenance being required for satisfactory system operation. System drawings, photos and data tables are included.

Awada, Minoru, Ramon S. de la Penta and Robert H. Suehisa (1986) Effects of nitrogen and potassium fertilization on growth, fruiting, and petiole composition of bearing papaya plants [s.l.] : University of Hawaii.

A study in Hawaii found that increasing nitrogen fertilisation rates increased the yield of marketable fruits, their growth rate and stem circumference. (However, beyond a certain level increases were not significant). Soil pH before the experiment ranged from 6.2 to 7.2 at 15 cm depth. Plants were drip irrigated through microtubes 40 cm from the plants. Soil conditions, fertilisation schedules and results are described and tabulated.

> If this is at all relevant, a more comprehensive 1979 document is available : Awada, M., I-pai Wu, R.H. Suehisa and M.M. Padgett. Effects of drip irrigation and nitrogen fertilization on vegetative growth, fruit yield, and mineral composition of the petioles and fruits of papaya
> [s.l.] : University of Hawaii.

Evans, Angela (1993) Eco-living in Sweden : inspiration for Canadian consumers and developers **Alternatives** 19:(2) p.7-8, 10

Three "eco-villages" in Sweden are briefly described. The villages are designed to consume less energy, use fewer toxic materials, and to encourage recycling, resource sharing and an improved sense of community. Included in the environmental activities is the collection, sand bed filtration and cistern storage of greywater from sinks, baths and showers and its ultimate re-use in irrigation of landscaping or greenhouses. No technical details are given, but the piece illustrates that Swedes must have accepted the concept of greywater irrigation and that standards must have been formulated. No specific mention is made of laundry water as being either included or excluded.

Farwell, Larry (1990) Grey water reuse In : **Proceedings of CONSERV 90 : The National Conference and Exposition Offering Water Supply Solutions for the 1990s** Denver : American Water Works Association.

The article acknowledges that while the practice is currently illegal, grey water has been used by millions of rural Americans over generations, mostly for watering landscaping or fruit trees. This has been without "a single recorded instance of anyone in the United States becoming ill from exposure to greywater". Subsurface application is to be preferred, in order to minimize the potential for disease transmission to humans and animals. A mini-leachfield ("a shallow trench partially filled with gravel and covered with weed-stop matting") is proposed. Its location would be along the plants' dripline. The need for system maintenance is stressed. The author recommends against storing grey water. Also, grey water should not include wash water from soiled diapers or water used by carriers of infectious disease.

Foster, Kennith E. and Martin M. Karpiscak (1990) <u>Greywater and its importance as a water supply in arid areas</u> In : **Proceedings of CONSERV 90 : The National Conference and Exposition Offering Water Supply Solutions for the 1990s** Denver : American Water Works Association.

The article suggests using subsurface application methods (drip irrigation or a mini-leachfield), to apply greywater to landscaping. This is in order to decrease the disease risk imparted by water-borne pathogens. Greywater includes "showers, tubs, lavatories and washing machine". The authors recognize that greywater can contain phosphates and other potential plant nutrients. Greywater treatments that have been tested at Casa del Agua in Tucson are outlined : water hyacinth plants, a sand filter and settling tanks. The current system (dual settling tanks and a sand filter) decreases bacteria levels by as much as 99%, although the treated greywater still does not meet Arizona standards for surface water reuse.

French, Chester D. (1972) <u>Papaya : the melon of health</u> New York : Exposition Press.

A personal account and anecdotal description of papaya : its cultivation, biology and therapeutic products. The most immediately relevant excerpt is that "papaya plantings are more successful in hilly or mountain terrain where soil is shallow, with good drainage", including Portuguese Africa.

Ingham, Alan Thane and Charles Franklyn Kleine (1982) <u>Cistern systems : the California perspective</u> In : Fujimura, Faith N. (ed.) **Proceedings of the International Conference on Rain Water Cistern Systems** Manoa, Hawaii : University of Hawaii

Greywater is defined as "all waste water generated in the home which does not contain toilet wastes". The article discusses the feasibility and advantages (lower water consumption, more localized cycling of resources) of including greywater in a rainwater cistern. Recommends that no contact be made with the grey water when it is used for irrigation, and that subsurface application be employed. The elements of the cistern and water distribution system include a greywater collector tank with dosing siphon, an intermittent sand filter, the sealed cistern (rainwater is directed from eavestrough, etc.), a submersible pump, a valved pressure tank and the subsurface irrigation system.

Karpiscak, Martin M., Richard G. Brittain, Charles P. Gerba and Kennith E. Foster (1991) <u>Demonstrating residential water conservation and reuse in the Sonoran Desert : Casa del Agua and Desert House</u> **Water Science and Technology** 24:(9) p. 323-330
(Issue titled : Wastewater reclamation and reuse; R. Mujeriego and T. Asano, eds.)

These projects in Arizona are being used to investigate and demonstrate techniques for water conservation and reuse. Three available sources of usable water are identified : the municipal supply, rainwater, and greywater. Greywater includes water from showers, tubs, lavatories and clothes washers. Casa del Agua has been operating longer, (since the mid-1980s), and the discussion concentrates on findings there.

The greywater system components at Casa del Agua include a plastic drum used as a sump surge tank, (the inlet is protected by a nylon stocking which provides filtration), a pump to direct water to two settling tanks (it is not clear why two, they seem to be parallel), a slow sand filter planted with vegetables, and finally a storage tank from where the water is pumped to the irrigation system. Subsurface drip irrigation is used to support arid-adapted species at Casa del Agua. Storage capacity has been provided in acknowledgement of the seasonal nature of demand.

The project tried using water hyacinths in the two settling tanks. This was effective in terms of water quality improvement, but encouraged nuisances (odour and insects). The hyacinths' evapotranspiration resulted in water losses. Electronic water purification devices were installed upstream of the tanks. The resulting water "virtually meet[s] most current wastewater discharge water quality standards".

A highly concentrated liquid laundry detergent is also being tested. The detergent contains no sodium and is purported to be biodegradable into plant nutrients.

Kourik, Robert (1990) <u>Source reduction for wastewater</u> **BioCycle** 31:(1) p.35

Gray water reuse was employed in some parts of California during the 1977 drought. Despite fears of diseases and parasites, an inspection revealed that no user of a gray water system became ill as a result. The grey water appears to have been chiefly (if not entirely) used to irrigate ornamental plants using subsurface application techniques.

Kuttab, Atallah S. (1993) <u>Wastewater treatment/reuse in rural areas</u> **Water Science and Technology** 27:(9) p.125-130

Although not specific to laundry water or even grey water reuse, this article is included due to its technical detail (sketches, costs, some dimensions) and possible climatic and political analogies to Angola. The treatment/reuse system, which includes a watertight septic tank and subsurface drainage field, provides irrigation water for surface plants. The technology has been adopted for use by individual households (average size 10 people) in the Occupied West Bank and Gaza Strip. Local materials were used, and the construction was done by villagers. "Samples of the surface soil and the plants cultivated are taken on [a] regular basis to check for any bacteriological contamination".

Lombardo, Pio (1982) <u>Expanding options for greywater treatment</u> **BioCycle** 23:(3) p.45-49

Lists, describes and evaluates (vis-a-vis various water quality parameters) greywater treatment possibilities. The technologies include septic tanks, sand filters, rack filters, biological treatment units, reverse osmosis, sedimentation/filtration schemes and physical/chemical treatments. Disinfection approaches mentioned are chlorine and iodine disinfection and ultraviolet irradiation. A diagram suggests that using greywater for irrigation does not require its prior disinfection. Recommendations include to :

- use irrigation as a disposal method,
- dilute and disperse greywater during application,
- avoid spraying,
- select appropriate plants (including fruit trees) and
- avoid "acid-loving plants" due to the presence of harmful salts in some greywater.

McGucken, William (1991) Biodegradable : detergents and the environment College Station : Texas A&M University Press

Interesting background reading on soaps and the development of synthetic detergents. Could be useful for general awareness of problems such as foaming that may result from some cleaning products.

National Small Flows Clearinghouse (1994) Computer search on greywater Morgantown, West Virginia : NSFC

I have highlighted relevant-looking articles in this 30-odd page bibliography. Many of the articles are old and not completely on topic.

Nishijima, Wayne (1983) Papaya diseases and their control In : **Proceedings : 18th Annual Hawaii Papaya Industry Association conference** [s.l.] : University of Hawaii.

Details the causes, results and control treatments (unfortunately chiefly chemical) for assorted papaya problems. Included are postharvest diseases of the fruits, seedling diseases, nematodes (roundworms), foliar diseases, blights and viruses.

Novotny, Vladimir (1990) Potential and prospects for reclamation of gray water In : **Proceedings of CONSERV 90 : The National Conference and Exposition Offering Water Supply Solutions for the 1990s** Denver : American Water Works Association.

The author presents a table of parameters measured in domestic gray water, commercial laundry, and typical total domestic sewage (BOD_5, COD, SS, Total N, Total P, total and fecal coliforms). It would be difficult to separate domestic laundry effluent from these categories. Recommendations include chlorination and/or aeration of stored greywater. The sodium content in detergents is mentioned as a problem affecting irrigated soils. Another problem with gray water is its bacteria content. The relative merits are listed for two treatment methods : septic tank with sand filtration or soil absorption, and chemical precipitation, sedimentation and filtration. Other possible treatments could include : "reverse osmosis, dissolved air flotation and several types of biological treatment".

Prillwitz, Marsha and Larry Farwell (1994) Graywater guide : using graywater in your home landscape (draft version) [Sacramento?] : State of California

This guide has been written to assist homeowners in designing and constructing their own system. The authors state that "graywater is untreated household waste which has not come into contact with toilet waste...[and] does not include waste water from...laundry water from soiled diapers". The system consists of a surgetank, mesh filter, pump and subsurface drip irrigation or mini-leachfield. The requirements for information gathering, designing and constructing the system are outlined. Although specific to California, the information could be translated to other contexts. The publication also lists potential soil problems, maintenance requirements and detergent evaluations (by brand name) and includes drawings, cost information and equipment checklists.

Purchase, Mary E. (1979) Water quality requirements for laundry and household needs In : **Third Domestic Water Quality Symposium (For Individual Water Systems)** St. Joseph, MI : American Society of Agricultural Engineers.

Lists and describes some water quality parameters (hardness, iron or manganese content, turbidity, colour, TDS, alkalinity/acidity, sulfur and temperature) and the effects that they may have on laundry activities, especially in regards to detergent or soap requirements. Some discussion of the relevant properties of laundry soaps and synthetic detergents vis-a-vis these parameters is included. The article is not terribly useful unless the laundry water is found to have an excess of one of these parameters.

Rockefeller, Abby and Carl Lindstrom (1977) Greywater for the greenhouse **Compost Science** 18:(5) p.22-25

The authors use a Lindstrom stone "roughing filter" to remove particles from kitchen wash water. Water is then applied through perforated PVC pipes set 2-3" below the soil surface in a 4' deep greenhouse soil box. Their experiences included noting the pH buffering capacity of the soil and the successful establishment of a small ecosystem in the greenhouse. The soil, even adjacent to the pipes, showed no sign of becoming anaerobic and plugging after six months of operation.

Rose, Joan B., Gwo-Shing Sun, Charles P. Gerba and Norval A. Sinclair (1991) Microbial quality and persistence of enteric pathogens in graywater from various household sources **Water Research** 25:(1) p. 37-42

The presence and persistence of microbial populations in graywater is evaluated. The graywater sources were shower/bath, laundry wash and laundry rinse cycles (of a washing machine). Indicator organisms (total and fecal coliforms) were measured. Sources were studied separately and as combined effluent, over a 2-3 month period. Another variable was family composition; specifically the presence and ages of children. Samples from families with young children showed more total and fecal colonies. Shower and bath water had more total and fecal coliforms than laundry water, except in one instance when a load of cloth diapers was washed. Results also included that greywater stored for 12 days increased in bacterial content over 48 hours before stabilizing. Likewise, when viruses responsible for dysentery, polio and salmonella showed some persistence in the water before stabilizing after 8-10 days. States that the 1984 Arizona standard for graywater reuse was a geometric mean of less than 25 fecal coliforms per 100 mL. Based on findings, treatment of graywater before reuse is recommended. Treatments could include "storage, sedimentation, filtration, biological treatment and disinfection".

Russell, Peter et al (1994) <u>Domestic water conservation : "The light grey option"</u> In : Shrubsole, Dan and Don Tate (eds.) **Every Drop Counts** (Based on Canada's First National Conference and Trade Show on Water Conservation) [s.l.] : Canadian Water Resources Association.

States that fruits and vegetables irrigated with grey water could absorb non-volatile chemicals and also become contaminated with micro-organisms. In-ground (ie subsurface) irrigation would lessen this risk. The focus of the paper is on subdividing grey water into "light" and "dark" categories, and implementing a cascading reuse system.

Serrano, Vitor M.B.L. and Richard C. Carter (1991) <u>Small scale irrigation in Angola : potential and promise</u> **Outlook on Agriculture** 20:(3) p. 175-181

This article describes Angolan water management practices, the types of land under cultivation and activities in the formal and traditional irrigation sectors, with special mention of the Planalto Central zone. The suggestion is made that irrigation statistics in Angola and other African countries under-represent reality by ignoring traditional schemes and activities. Two distinct soil types are identified in the country : upland and river valley bottom soils, the latter being "more suitable for irrigation".

Siegrist, Robert L. (1987) <u>Soil clogging during subsurface wastewater infiltration as affected by effluent composition and loading rate</u> **Journal of Environmental Quality** 16:(2) p. 181-187

This research took place near Madison, Wisconsin. The soil used was a well structured, silty clay loam (9% sand, 51% silt, 40% clay)*. Grey water septic tank effluent ("domestic wastewaters less toilet waste") applied at 5.2 cm/day clogged soil and led to water ponding. Application was through a subsurface infiltration system. After 62 and 70 months of loading, soil near the surface was found to have accumulated organic materials (organic carbon).

* this represents a much higher clay content than reported in Angola would therefore be potentially more disposed to clogging

Stephenson (1992) <u>Tropical fruit production in the Southern hemisphere</u> **Acta Horticulturae ; no.321** p. 44-55

The article is not terribly useful, and a copy has not been included. It states that papaya fruits are difficult to handle (for marketing) because of their soft flesh and a propensity to develop ripe fruit rots.

> Generally, I notice that "ringspot virus" seems to get a lot of research attention in the indexes, in reference to papaya or pawpaw.

Venhuizen, David (1990) Greywater reuse on a university campus and Low cost, low maintenance on-site/small scale wastewater treatment and reuse In : **Proceedings of CONSERV 90 : The National Conference and Exposition Offering Water Supply Solutions for the 1990s** Denver : American Water Works Association.

The author makes preliminary suggestions for the treatment of greywater from campus residence halls. The grey water sources are not identified. Treatments could include a "settling (septic) tank, an anaerobic upflow filter and/or short detention gravel marsh, and an intermittent sand filter and/or slow sand filter". This treatment sequence would render grey water suitable for subsurface drip irrigation. It could also handle variable loads and stop and start operations, with the major concern being clogging.

Washwater Garden provides household water-saving a green thumb (1994) **U.S. Water News** 11:(3) p.13

This brief article outlines a "sealed" system using filtered graywater available from the Concord, Mass. based *Water Conservation Systems, Inc.* The system meets California, Nevada and National Uniform Plumbing code requirements for gray water irrigation. The system was partially developed and tested at the University of Toronto, and has been "recently utilized in the Pacific islands of Micronesia". The starting point for water reuse is the with diversion of washing machine water. The system is touted to be great for arid climates and areas experiencing water shortages. It would seem to be a leachfield / perforated pipe in trench arrangement.

7.0 List of Reference Sources Searched

7.1 On-line Indexes

Agricola : 1984-most recent
CAB Abstracts : all available
CBCA : all available
Dissertation Abstracts : all available
Life Sciences : all available
Science Citation Index (CD-ROM) 1990-93 (1993 is latest available)
WaterWiser computer search results (the listing could be included : I have examined all of the pertinent citations)

7.2 Printed Indexes

Agricultural Engineering Abstracts
Biological and Agricultural Index : 1993-current
Engineering Index : 1987-current
Environmental Abstracts : 1992-94
Horticultural Abstracts : 1993-current
Irrigation and Drainage Abstracts : 1993,1994
Soils and Fertilizers : 1993-current
Waste and Environment Today : a bibliographic journal : 1993-94

8.0 Contact Names

Steve Banc (sp?) at Canadian Water and Wastewater Association
Ottawa : tel 613-241-5692; fax 819-241-5193

George Eastwood at Waste Water Technology Centre
Burlington : tel 905-336-6469
Mr. Eastwood says that there are no standards in Canada for greywater use. We discussed possible clogging problem of clayey soils. He described an irrigation method that he had worked with where perforated pipe in a trench is covered by an inverted larger half pipe section then backfilled. The small ecosystem developed between the two pipes contains bugs and worms that keep the soil open and allow water penetration.

Linda Elinoff at WaterWiser : the water efficiency clearinghouse
6666 West Quincy Avenue,
Denver CO 80235
tel 1-800-559-9855; fax 303-795-1440; e-mail lelinoff@csn.org

Marsha Prillwitz at California Department of Water Resources
P.O. Box 942836,
Sacramento, CA 94236-0001
tel 916-327-1620 fax 916-327-1815.

Small Flows Clearinghouse (contact : Murdi Sinsal (sp?))
West Virginia : tel 304-293-4191

Water Conservation Systems Inc.
Concord, Massachusetts : tel 508-369-3951