GREY-GREEN SYSTEM – A COST EFFECTIVE GREY WATER REUSE ALTERNATIVE

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Abstract

Application of a compact grey water system (Grey-Green System) results in a cost effective program for reduced volume of wastewater requiring treatment and decreased use of pristine potable water for sustaining vegetation. As much as 50 percent of a household’s wastewater flow is grey water and available for reuse. Grey water reuse has historically been bogged down by requirements for lint screens and overflow connections to the black water system. While these components are necessary, typical grey water system size resulting from traditional components and cost resulted in no grey water reuse or illegal grey water reuse.

Cost effective reuse of grey water can be accomplished by a single unit integrating requirements for screening, overflow and a pump in a 12-inch diameter by 24-inch to 36-inch height process unit. Water flows into the unit and then to a trough with a screened bottom. Water falls through the screen to the bottom of the sump where a grey water application pump, actuated by water level is present. The pump discharges the screened grey water to user selected locations via a conventional water hose. Grey water continues to flow laterally in the trough across the sump to the discharge port and into the black water system if the screen is blinded or pump failure occurs.

Screening exhibits the biggest challenge with grey water. Accomplishing grey water screening on a modest budget and requiring little to no home owner input or programmable logic controllers and control valves can be accomplished by an up-flow, side-washed screen.

Cost effective and easy reuse of grey water will provide for less demand on water supplies and reduces the load on wastewater treatment units.

Introduction

Citizens of the United States of America comprise a thoughtless society, blindly using pristine water suitable for human consumption to flush our toilets and water our lawns. Grey water is a suitable alternative for both of these water uses. Grey water is domestic wastewater originating from bathing and laundry sources. It does not include wastewater originating from toilets, urinals, kitchen sinks or laundry water with fecal materials. Grey water is typically not recovered and reused because there is no incentive to do so and it adds costs to a wastewater treatment system. Combined grey water and black water piping also add complications to grey water reuse.

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The Grey-Green System is a first step towards a cost effective and compact system for outdoor residential grey water recovery and reuse. This a trademark name assigned to a small lift station with an internal screen that provides an alternate source of water for vegetation. Grey water recovery and reuse is applicable to sources where grey water piping is separate from the black water piping or easily separable, black water piping is nearby and located downslope of the grey water system, and vegetation is present that can beneficially reuse the grey water. A Provisional App No.: 61/994,057, filed on May 15, 2014 has been made for an In-Line Grey Water Utilization System, marketed as the Grey-Green System (Notice of Allowance: U.S. Trademark SN 86209639).

Traditional methods for grey water reuse in landscape applications include the following:

- A 300-gallon to 500-gallon concrete tank;
- Submersible pump;
- Lint screening device;
- Overflow to the black water system;
- Chlorination device (in some jurisdictions);
- Distribution hose;
- Electricity; and
- Backhoe or excavator for installation.

The installed cost of the aforementioned grey water recovery system may approach $3,000, assuming that additional plumbing effort is not required to separate the grey water from the black water system.

The homeowner must clean or maintain a lint removal device to keep the unit operating properly and move the discharge hose to distribute the grey water without creating a nuisance condition.

Most homeowners decline grey water recovery and reuse because of the cost, disruption and effort. However, grey water use provides for a two-fold benefit because potable water is not expended to water vegetation and the operating expense to treat grey water in the Public Owned Treatment Works (POTW) or Onsite Sewage Facility (OSSF) is not incurred.

The objective of the development of a smaller system is to provide a new generation of grey water recovery and outdoor water reuse as follows:

- Capital cost of less than $1,000;
- No backhoe required for installation;
- Compact and lightweight unit capable of being installed with hand tools;
- Automatically backwashed lint screen to eliminate a settling tank and minimize user input;
- Utilize grey water as it is generated to decrease volume requirements for storage and decrease the likelihood of odors with degrading grey water;
- Provide for backflow prevention from black water system piping;
- Structurally sound vessel; and
• Provide overflow to the black water system for periods of non-use or pump failure.

**Materials and Methods**

The materials are off-the-shelf by design to keep capital costs low and fabrication simple. The system is a sump, containing a pump, the treatment process, an overflow and a backflow prevention device. The treatment device is an automatically backwashed horizontal screen. Figure 1 presents a section view of the unit.

![Diagram of the Grey-Green System Section](image)

A summary of the components is as follows:

- 12-inch diameter SDR 35 PVC pipe sump;
- 110 volt electric submersible pump with automatic on-off level controls;
- Pump discharge piping consisting of PVC piping and a flexible hose for grey water application;
- A slip stream off of the discharge piping that is focused on the underside of the horizontal screen to provide simultaneous backwash with wastewater screening;
• A horizontal screen fabricated with 1/8-inch square galvanized hardware cloth and 18 X 16 mesh aluminum window screen; and
• Two PVC swing check valves.

A 12-inch diameter sump was selected because it is the smallest size that will accommodate a small commercially available electric submersible pump. A four foot sump height was selected to provide about a foot of working volume between the top of the 12-inch height pump and the inlet flow piping and two feet above the inlet piping to extend the sump access above the ground surface, for a total sump height of four-feet.

Approximately two-feet of the existing grey water piping from the residence must be removed to facilitate system installation. The 12-inch diameter pipe is fitted with a cap on both sides to form a sump and the pipe is installed vertically below ground, in-line with the grey water system piping. Connection to the sump is made by saddle connections and connections to the grey water piping by rubber boot type adapters.

A screen connects the inlet piping to the discharge piping facilitating water flow downward into the sump after screening or continuing to the sump discharge if the screen is blinded. The screen is removable to provide sump pump removal from the sump or screen removal for manual cleaning.

Two swing check valves are installed outside of the sump in series prior to connection to the black water system. The swing check valves prevent black water flow from back flowing into the unit.

The sump pump with automatic level controls is installed in the bottom of the sump. The working sump volume is about 10 gallons, but with the added level controls, the pump is able to recover all of the grey water from each clothes wash cycle for reuse. The automatic level controls provide for pump on operation as water rises in the sump and pump off when water drops to a predetermined set point, which is about two-inches above the sump bottom. The sump pump is a Hydromatic D-A1 and the system curve is provided as Figure 2.
Hydraulic estimates indicate that the pump should operate at about 10 gpm. The actual pump discharge rate ranges is about 6 gallons per minute (gpm) with a 20-foot length of 5/8-inch diameter water hose attached to the unit and approximately two feet of static head.

Aluminum window screen underlain by 1/8-inch square galvanized hardware cloth are used for the screening unit operation. The window screen serves as the screening mechanism and provides for 18 X 16 mesh or an opening of about 1-millimeter (0.038-inch) opening. The hardware cloth serves as structural support for the primary screen. The screen size was selected based on common availability and low cost of window screen wire, instead of a particle size analysis of grey water. A clothes dryer screen has a 32 mesh opening (0.5 millimeter) for comparison purposes.

The screen assembly is rolled to 360 degrees of a circle and fastened with hose clamps to the influent and effluent pipe that extend inside of the sump. Accordingly, flow enters horizontally, then downward through the screen into the sump. The flow continues horizontally to the black water discharge if the screen is blinded.

Backwash is accomplished by a slip stream from the pump discharge focused at the bottom of the screen. The backwash loosens the collected lint and the incoming flow pushes the lint to the black water discharge side of the sump.

PVC piping connects to the sump pump and discharges vertically inside the sump to provide a location for exiting the sump above the ground surface and connection to a flexible hose to provide for user selected grey water application locations. The grey water application hose a common garden hope with purple color and must have a plain end (no threads) such that a nozzle or other potential aerosolizing device cannot be installed on the hose.
The pilot unit was installed at a 2,500 square foot residence with five bedrooms and dedicated grey water flow from a top load clothes washer and combination laundry/bathroom sink.

The clothes washer is a Speed Queen Commercial Heavy Duty washer and the laundry/bathroom sink is fitted with a conventional kitchen faucet with water savings devices. The clothes washer generates up to 16 gallons per cycle (32 gallons per load) for the maximum setting and the maximum flow rate is about 15 gallons per minute. The sink faucet can discharge approximately one gallon per minute. The clothes washer discharge is the design worst case hydraulic condition.

The grey water application area is a raised citrus tree garden with approximately one-foot of bank run sand overlain by four-inches of 1 ½-inch to 3-inch gravel. Underdrains are present beneath the sand layer.

Occupants in the house ranged from three to six persons and loads of laundry per day ranged from zero to five loads, with an average of two loads per day.

The pilot unit was installed on January 15, 2015 and operated real time with household operations and their random nature. The unit is still in operation.

**Results**

The effectiveness of the pilot unit was qualitatively evaluated for the following criteria:

- Cost;
- Constructability;
- Operability;
- Recovery Volume;
- Pump Performance;
- Screen Effectiveness;
- Backwash System Effectiveness;
- Overflow/Bypass Performance; and
- Vegetation Response.

A discussion of the results for each of these qualitative criteria is as follows:

**Cost**

The pilot unit was fabricated for approximately $500. Most components were purchased at retail price. It is likely that fabrication costs can be reduced with mass production, volume purchasing or possibly injection molding of the system. A retail price for the unit will likely range from $500 to $1000 which is a reduction by 66% to 85% of traditional methods.
**Constructability**

The pilot unit was fabricated with off-the-shelf parts available at plumbing supply and hardware stores. Equipment needed to install the unit included a shovel, posthole digger, a saw and a 5/16-inch socket and driver. The electrical supply for the pilot test was an extension cord connected to a GFI receptacle. A permanent electrical supply routed in underground conduit and complying with electrical codes will be necessary for residential applications. The time to install the unit (fabricated unit) was less than two hours in sandy soil.

**Operability**

Screening, pumping, backwash, bypass require no operator input. The unit receives grey water at the end of the wash and rinse cycles and automatically discharges the water. The unit operated without failure during the testing phase. The unit did not overtop during the pilot testing period.

The diaphragm actuated submersible pump starts and stops based on sump level and performed without failure. The pump was pulled once for inspection during testing. Biological growth was present on the pump and diaphragm switch but did not appear to affect its operation. The pump’s screen was not blinded. The pump and switch were washed as a preventive maintenance type measure.

Placement of the discharge hose at areas selected for watering in advance of performing laundry is appropriate, but not necessary. The hose may be moved during unit operation.

There were no odors associated with unit because water is distributed as soon as it is generated.

**Recovery Volume**

The system recovered from 90 percent to 100 percent of the water from each wash cycle, typically 12 to 16 gallons. Reduced recovery volumes were observed when the screen began blinding and some water bypassed to the black water system.

**Pump Performance**

The Hydromatic DA-1 submersible pump performed without failure during the test period. There is one pump start and stop cycle per clothes washer discharge cycle which is necessary to extend pump life. Numerous pump start and stop cycles reduce pump life.

The diaphragm switch performed without any failures during the testing period. It is recommended to pull the pump at six month frequencies and wash the switch and the pump.

The pump discharged grey water at a rate between six gpm to eight gpm. There was little to no bypass to the black water system for the pump discharge rate of six gpm because the sump volume is about five gallons and the clothes washer discharge cycle for the 16 gallons is about two minutes.
Screen Effectiveness

The lint screen was observed three to five times per week during system operation to evaluate its effectiveness. The grey water application area was also inspected for signs of excessive lint from the discharge.

Lint and other debris from the clothes washing process were retained on the screen. Generally, the lint was a very fine slimy material that filled the spaces of the screen. The screen exhibited deposits on the influent side and extended to the discharge overflow side with run time. Water present in the sump appeared to be of good quality and did not exhibit suspended solids or excessive solids deposits in the sump.

Recovered grey water was discharged into buckets to facilitate a visual analysis of the screened water. The recovered water was also void of suspended solids (lint).

Water discharged to the raised bed did not exhibit lint or nuisance solids on the rock surface after six months of operation.

Backwash System Effectiveness

The backwash system facilitated a run time of about two weeks before the screen was blinded. The current backwash system appears to be too focused on limited areas of the screen and will be improved to increase run time before blinding. The screen can be manually removed for cleaning. However, this may be too much input for homeowners.

Overflow/Bypass Performance

Visual observations of the overflow/bypass from a blinded screen demonstrated acceptable conveyance of the grey water to the black water system. Black water did not enter the unit during the operation period.

A separate test with the pump off and discharging water to the sump demonstrated that a water level rise of five-inches was necessary to open the double check valve system on the overflow/bypass system.

Accordingly, a riser of a minimum of five-inches above the bottom of the screen is necessary to open the valves and discharge grey water to the black water system.

Vegetation Response

Commercially available laundry detergents including Tide Pods and Gain Powder, as well as a homemade liquid soap were used in the residence where the system was operated. Recovered grey water containing these soap residues was applied to a raised garden containing lemon and orange trees and blueberries. The grey water and naturally occurring precipitation were the only
water source to the raised garden area. The citrus trees and blueberry bushes did not exhibit adverse effects from the grey water and are bearing fruit.

**Discussion**

A new approach to grey water recovery and reuse has been developed that for practical incorporates a coarse screening device into a small lift station. The unit handles the grey water as it is generated and purposefully does not store the water in order to maintain a small process unit to keep costs down and to decrease development of odors associated with stale grey water.

The unit has operated for nine months in an acceptable manner. Water may be used for landscaping, fruit trees or maintaining moisture around foundations. Despite the obvious uses of the grey water, the unit provides the following additional benefits:

- Provides for beneficial diversion of grey water from a failing system;
- Provides for reduction of the amount of water purchased for landscaping and foundation watering; and
- Provides for conservation of potable water resources.

The estimated retail price of the unit ranges from $500 to $1,000. Sadly, the unit has a payback of in excess of ten years at current potable water purchase rates. However, when drought contingency plans are implemented and potable water is not available for outdoor watering, the value of the recovered water increases significantly.

The unit presents the basis for treatment systems with a smaller footprint and trying to do more with less. The system provides for coarse screening inside of a small lift station. It appears that an external screen system may be more appropriate to facilitate easier access to the filter screen for cleaning.

The grey water system has operated without mechanical issues for nine months during pilot testing. During that time lint has accumulated on the screen and the side-washing action has provided sufficient cleaning such that most of the grey water has been recovered for beneficial reuse.

There were no issues or failures related to freezing weather conditions. The system components are below ground or drain at the end of a discharge cycle. Accordingly there are no piping or equipment components that will freeze and fail.

The system also provides a suitable alternative to recover and reuse air conditioner condensate. The addition of a sand filter and pressure storage tank will provide water suitable for indoor water reuse.

It seems that water has been taken for granted and perceived as an unlimited resource in most parts of this country. Recent severe droughts and an ever growing population are beginning to change the water perspective. It is time for widespread grey water reuse to decrease potable
water demands and to decrease the volume of wastewater requiring treatment and disposal as a secondary benefit.

On a recent brighter note, the Texas Legislature recently passed House Bill 1902 that relates to the regulation and use of greywater and alternative on-site wastewater. The bill amends Chapters 341 and 366 of the Health and Safety Code and Chapter 26 of the Water Code in relation to the use of greywater and alternative onsite wastewater.

The bill requires the Texas Commission on Environmental Quality to develop standards for both the outdoor (currently allowed) and indoor use of greywater (specifically for toilet and urinal flushing). The bill creates a new regulatory program for “alternative on-site wastewater and directs the TCEQ to develop similar standards for this new source of water similar to greywater. Additionally, the bill allows an adjustment in the size of an on-site sewage disposal system when used in conjunction with a grey water system.

NSF/ANSI 350-2014, Onsite residential and commercial water reuse treatment systems, provide a standard that addresses grey water reuse. The standard provides a step in the right direction for beginning grey water reuse. It provides a performance criteria for indoor and outdoor grey water reuse, but does not appear to set a lower standard for outdoor water reuse. NSF/ANSI 350-2014 indicates that treatment systems with a capacity less than 400 gallons per day are not required to meet the performance standards of NSF/ANSI 40.

The system targets outdoor water reuse for less than 400 gallon per day residential sources. It is likely that the effluent quality of the system will not meet the effluent standards of NSF/ANSI 350-2014 or NSF/ANSI 40. However, it does not seem necessary or appropriate to expend capital or operating resources to achieve those standards for outdoor water reuse, when the environment will provide a suitable treatment for the typical residential grey water waste strength and volume.

The system provides a low cost recovery and distribution of grey water with screening for gross solids (lint) removal and is compliant with current regulation in Texas. Its applicability in other states has not been assessed and it is unknown how the system will fit in future regulation. Additional unit operations can be added to the system to achieve effluent criteria compliant with NSF/ANSI 350-2014, if appropriate. However, more stringent effluent criteria will result in higher capital cost.

More stringent criteria are appropriate for indoor water reuse. As environmental agencies move forward to address water reuse, it is necessary that separate criteria be established for indoor versus outdoor water reuse. The Grey-Green System is ready to begin a thoughtful reuse of potable water in place of pristine drinking water.
**Literature Cited**


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