CCAT greywater marsh (2008)

From Appropedia

(Redirected from CCAT Greywater Marsh)

Introduction

Greywater Basics

Greywater is treatable household wastewater, usually from bathroom sinks, showers, bathtubs,

Contents

and washing machines. Wastewater from toilets or water used to wash cloth diapers should be considered blackwater, and must be handled and treated with care and separate from greywater treatment and reuse. Kitchen sinks are also a point of contention, due to the high concentration of organic matter, or food waste. California law stipulates that kitchen sink water is separate from greywater treatment, but due to the plumbing design at the CCAT facility this system includes the kitchen sink. Care must be exercised to limit the amount of organic matter and cooking oil that is allowed to flow down the drain. The household greywater is piped to a subsurface rockmarsh, where marsh plants and their symbiotic

microorganisms clean the wastewater for irrigation reuse. Bacteria and microorganisms living within the root structure of marsh plants, typically bulrush and cattail, break down organic matter to its constituents: food, carbon dioxide, and benign organic compounds, such as salts. This organic matter present in our greywater is from detergents, skin cells, food waste, etc. See the general Greywater page for more information.

Project Background

The Campus Center for Appropriate Technology (CCAT) was relocated and remodeled in 2007, and has been reinstalling its technologies throughout the process. It was the hope of the organization to construct a greywater treatment marsh for self-sufficiency, water conservation, and to demonstrate greywater treatment and reuse at the facility and at Humboldt State University. This marsh was an ENGR 305 project, and is the culmination of much research, design, and construction of a

system appropriately sized and designed for CCAT's needs and irrigation capabilities. This project has the ability to effect years of future demonstration and learning opportunities, and CCAT hopes that future projects will benefit from the treatment system, end-use irrigation, and the landscaping abilities on the CCAT site (See #Future Projects Section for further details).

System Description

Greywater Outlet

During renovation of the CCAT house, plumbing was designed to divert greywater from blackwater; making it easier for the future greywater project. This outlet is located 3' beneath the ground.

Sedimentation Basin and Grease Trap

The sedimentation basin and grease trap are utilized to separate larger particles, fats, and oils before greywater

treatment. Our system is comprised of a 55-gallon drum of food-grade plastic. Food-grade plastic was used to ensure that no leachate would enter the treatment marsh; it is also important that the barrel was not previously used to hold petroleum or hazardous waste.

Due to the placement of household plumbing, the barrel was situated next to the greywater outlet, 4' below ground level. Water enters the barrel and is immediately filtered through a sock, so larger particles do not have the chance to enter the system. This sock must be removed and cleaned every two weeks. Because this is a maintenance concern other ideas and designs have been considered, but none have been constructed. This is an opportune area for future progress. (A woodchip biofilter could potentially replace a sock, see: http://greywateraction.org/content/woodchip-biofilter-kitchen-sink-wetlands)

After the greywater is filtered through the sock, it fills the

barrel and exits through the grease trap. We designed a simplified grease trap which forces water to enter a 2" ABS pipe below the waters surface, keeping fats and oils floating above the pipe inlet. This will keep grease separate from the treatment marsh, and must be skimmed clean monthly. Because the grease trap design forces water down and back up, a siphon must be started by bleeding the system of air. A airtight cap must be added to the grease trap pipe, and closed after initial fill of greywater. If the system dries and air enters to grease trap pipe again, the cap should be opened and the

system bled again.

Pipe to Marsh

A 27' long, 2" ABS pipe, within a 3" sleeve, transports greywater from the Sedimentation Basin to the Surge Tank. A driveway was constructed between these two components, necessitating the need for the 3' deep trench and associated piping.

Fig 1:Sedimentation basin and pipe trench

Surge Tank

Surge Tanks are required in greywater treatment systems because they create a place for the quick release of greywater from the house. Without a surge tank, you're likely to have a bathtub and washing machine that drain slowly; keeping your

ankles in dingy bath water for longer than is comfortable!

Our surge tank is comprised of a 35-gallon food-grade plastic barrel, lying on its side to reduce the loss of head and elevation within the system. 2" ABS pipe enters and exits the base of the surge tank, so no water will sit and stagnate in the barrel, but will fill while allowing for the slow percolation of greywater into the marsh.

Surge tanks should be sized to adequately respond to the release of water from your household fixtures. Keep in mind the capacity of your bathtub and washing machine, both are usually 30-40 gallon capacities. Since water will not be sitting in the surge tank, this is the only component of marsh construction that can be over-sized. Our surge tank would be too small to handle the coinciding release of the bathtub and washing machine.

The surge tank should be maintained monthly, with the cleaning of the grease from the sedimentation basin. There is a small opening in the top of our surge tank, a hinged door

should be added, and pressurized clean water can hose down the interior of the tank and be allowed to slowly flow into the marsh.

Fig 2: Surge tank and marsh inlet

Gravel Marsh

The marsh is considered a subsurface rockmarsh, due to greywater treatment being entirely below the gravel surface. In this system, greywater will never daylight, or surface, eliminating much risk of contamination with stormwater, wildlife, and human interaction.

Surfacing greywater has the ability to aerosolize, or release contaminant particles into the atmosphere, which can be inhaled by humans, causing respiratory irritation.

Treatment within the marsh is primarily dedicated to the microbial action within the root structure of the marsh plants. We chose to use bulrush and cattail plants because they work

best for subsurface gravel applications; they can also be found locally, and are the most commonly utilized plants for marsh and wetland treatment. We retrieved our individual plants from the local tributary system because they have already established a microbial community within their root structure. At the time of transplant, Arcata was experiencing unseasonably high temperatures. If the shock is too great for the current plants, there are replacements being cultivated in a bathtub on CCAT's grounds.

The actual treatment area of the marsh is 4' wide by 14' long by 3' deep, or approximately 1250 gallon capacity. To facilitate movement of greywater through the rockmarsh, baffles are added. Baffles are barriers that direct water flow and maximize surface area therefore maximizing treatment area. Without baffles the majority of greywater would find the quickest route out, not having sufficient treatment time, while some greywater would creep into dead zones, becoming stagnant and anaerobic. As greywater enters the marsh from

the surge tank, it hits a few large rocks to quickly infiltrate the surrounding gravel. Movement is impeded by the first baffle; water flows under this baffle until it reaches the second baffle, the base of which is along the bottom of the marsh. Greywater flows over this baffle, and repeats similarly past all baffles, until reaching the exit pipe. Five baffles direct the flow, two along the base forcing greywater up and over, and three at the top, forcing water down and under. The baffles are made from half-inch OSB, particle board, from a deconstruction project. To discourage degradation from constant contact with water, the bottom baffles were installed under the pond liner, and the top baffles were wrapped in excess pond liner.

Pond liner ensures that greywater would not infiltrate groundwater. Other marsh projects have experimented with clay bases, but none of these systems have proved as effective as pond liner, although we would have liked to reduce our dependency on petroleum products during the

construction of this treatment system.

Because the system is gravity-fed and located on a steep incline, the marsh is a few feet below ground level, which will require future terracing and landscaping. Care should be taken to encourage stormwater runoff around the marsh, because it is not sized to handle seasonal fluctuations from surface runoff.

End Use

An irrigation system will be designed by a future student project. Due to the elevation of the greywater marsh, there are limited options for landscaping. The future system may include an electric or hydraulic pump to increase the irrigation options, but there should be a system to utilize the greywater in case a pump malfunctions.

Construction

Detail

Fig 3:Subsurface marsh with baffles

Diverting Greywater

We started by digging a hole 5' deep by the greywater outlet for the sedimentation basin to sit in. The 3' tall, 50 gallon basin rests in the bottom.

From the House to the Marsh

After this, we dug the trench from the outlet to the marsh location. The trench was 3' deep and 27' feet long. The trench was started during the previous semester. *Don't underestimate how long it takes to dig by hand.*

Extra Plumbing

We placed 2" piping inside a 4" sleeve in the trench. The

sleeve was required by HSU Plant Operations because a driveway needed to be built over it.

Fig 4: Outlet pipe for future end use

The Big Hole

We marked the shape of the marsh and the hole for the surge tank (located between the trench and the marsh itself), and started digging. To accommodate the calculated flow from the house, we needed a marsh 10' long, 4' wide and 3' deep. We decided that based on the slope of the adjacent hill, we would need to dig a hole 5' deep in order to have a marsh 3' deep.

Baffles? Baffles!

We cut out baffles made of plywood and hardwood to about 4' wide, 2.5' high and lined the 3 top baffles with pond liner in

hopes of delaying decay. We installed the bottom two by wedging them in the dirt.

Pond Liner

At our local landscaping store, we purchased a 23' x 10' cut of pond liner. We calculated this size by figuring the area of the marsh walls plus the area of the two bottom baffles, and an extra foot on all sides (it might be a good idea to calculate an extra 2' on all sides as the liner shifts when you start filling it with gravel). It was helpful to tack the edge of the liner into the ground when filling it. After the liner was in, the 3 top baffles were installed: one a foot from the marsh inlet, one a foot from the marsh outlet, and one smack in the middle of the two bottom baffles. the bottom of the top baffles were placed approximately 6" from the marsh floor.

Gravel

We started the task of filling the marsh with gravel by holding

the upper baffles in place while another person shoveled/dumped gravel into it. It is very important to pay attention to your pond liner height on all sides as you are filling! We left about a foot of room at the top before we started planting. We allowed room for 1' of gravel to be placed on top of the water level, so the marsh would have a completely sub-surface flow, which is important if you don't want the greywater to aerosolize and potentially create respiratory issues.

Planting

Bulrush, a marshy plant that loves filtering greywater, was found at local marshy areas. We planted these straight into the gravel, at 1' and 6" from the top. We planted approximately 30 plants, dispersed from the 1st upper baffle to the outlet. We watered these thirsty plants after transplant and will continue to whenever they look dry until the greywater starts flowing from the house.

Sedimentation Basin and Grease Trap

This system was constructed from a 55-gallon drum, and some ABS pipe and fittings. Self-locking gaskets were used for inlet and outlet, and ABS glue was used to glue grease trap pipes together. Once filled with greywater, the grease trap must be fitted with a locking valve to bleed the sir from the pipes.

Surge Tank

The 35-gallon drum used the same self-locking gaskets as the sedimentation basin. During construction a hole was cut into the top of the tank to connect inlet and outlet pipes, and the hole will ease maintenance in the future, but this hole should be outfitted with a closing lid to keep errant particles from entering the system.

End use

The greywater crew and CCAT community agreed that the end

use of the treated greywater deserved to be a project in itself, with as much thought and planning as went into the greywater treatment alone. To be continued...

Plans

Here the AutoCAD drawings for the marsh layout. *Be forewarned though, this is my first endeavor into AutoCAD, and the plans may resemble the work of a 2nd-grader (no offense to 2nd-graders).*

Maintenance and Testing

Maintenance

Sedimentation Basin

The sedimentation basin needs to be monitored fairly frequently at first. The sock needs to be emptied as it fills

with organic matter (such as hair and food scraps from the kitchen sink). We predict this task to be done once every two weeks.

Surge Tank

This needs to be cleaned out periodically. We will start by cleaning it once a month and monitoring buildup. This tank can be cleaned with pressure washing by putting a hose in the top hole and power washing the gunk out.

Gravel Marsh

This can be cleaned every 3-4 years by taking the gravel out, rinsing it, and putting it back in. The plants can be taken out and placed in buckets of water during cleaning and replanted afterwards.

End use

The maintenance for end use will be determined when an

irrigation technique is established.

Water Quality Testing

It is important to test the treated greywater for Biological Oxygen Demand (BOD) and Fecal Coliform to make sure the treatment is effective. After the marsh is activated, the plan is for a CCAT employee to conduct these tests once a week at first, keeping in mind how the temperature and precipitation affects the effectiveness of treatment. From here, we can decide on a more reasonable schedule for water quality testing.

Future Projects

The treatment marsh has been completed, but will need future student projects to irrigate with the treated water. The entire treatment system has been gravity fed to the final outlet pipe. This has resulted in the outlet pipe being 4' below grade. If the

end use is to be gravity fed as well, the irrigation pipe must be laid downhill from the marsh outlet, limiting the amount of irrigated landscape. It is possible to include a pump, so that treated greywater can be pumped to higher ground. This decision is ultimately up to the CCAT community and the future student designers. Pumps do break and malfunction though, and there should be a backup plan for the accruing greywater in case of necessary pump maintenance.

Plant choice is important when reusing treated greywater. Greywater should never daylight, all irrigation should be subsurface. This way, treated water will not be sprayed on edible foods, or come into contact with human and wildlife. Edible root crops and leafy vegetables should not be irrigated with treated greywater. Orchard trees, vining plants, and ornamentals typically receive treated greywater.

There will be numerous other opportunities for continuous education and support. Contact CCAT to be involved with the

irrigation design and construction, sedimentation filter design and construction, necessary landscaping and terracing, interpretation and signage, and so much more.

Vision

Now that this project is complete, I have the benefit of hindsight to realize that this marsh could have been constructed more effectively and efficiently. Due to CCAT's reconstruction, all of the facility's greywater has been piped to one manhole, 4' below grade. This limited our marsh location, and treatment and irrigation methods. If this system is to be altered in the future, I would separate, treat and reuse the facility's greywater before it is all piped underground. The majority of utilities generating greywater are located on the periphery of the house, where cuts into the exterior plumbing can easily reroute greywater outside, without piping it far from the house and losing potential head. Below is a short list of each utility, and how I would more

effectively treat its greywater.

Kitchen sink

The kitchen sink is located on an exterior wall on the north side of the house. With a hole-saw, a cut into the house siding would liberate the greywater piping. A small sedimentation basin and grease trap would be located against the house, for ease of maintenance, and an outlet pipe could run across the pathway to the north slope gardens. Some modification would be needed so that individuals (and wheelbarrows) didn't trip over the greywater pipe. A small subsurface rockmarsh, made from a series of sinks or 5-gallon barrels, would treat the sink water. The downhill landscaping, along the driveway, would be irrigated with perforated PVC piping.

Bathroom sinks

The downstairs bathroom sink could remain on the original

greywater plumbing, because the downstairs toilet already has a reused hand washing system. The upstairs sink water could be routed to the neighboring toilet, to flush with greywater.

Bathtub

The upstairs shower is conveniently located above the downstairs bathroom and mechanical room. A system could be designed so that the shower water was piped the the downstairs mechanical room. By preserving head, a surge tank then sand filter could be engineered on a rack near the ceiling in the mechanical room. The filtered greywater could be stored in a tank above the washing machine, and gravity fed into the machine for laundry time.

Washing machine

The greywater produced by the washing machine is already in the original greywater plumbing. A small marsh could have

been constructed out of a below ground bathtub, to treat the laundry and bathroom sink water.

All of these systems can be easily constructed using a majority of salvaged materials, this time no pond liners! Also, all end use would be gravity-fed, no need for pumps. Each utility could be tackled by an individual student project to ensure that each system received the energy and attention it deserves. CCAT is a demonstration house and all technologies should be available for duplication at other sites. Most residences do not have the space available to build a subsurface rockmarsh, but many could spend a few weekends, separating and treating their greywater at individual utilities. Because of the demonstration aspects of this project, and the limitations posed by the elevation of the greywater pipes, I would have treated and reused the greywater in a much different manner.

Special Thanks

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