ALEGRÍA
VILLAGE

Ordinary Wastewater Disposal and Treatment Manual

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AURORA
INGENIERIA Y AMBIENTE

INTRODUCTION

The Manual you are reading was made for you and your family because we want the rivers and springs to always sing. May the water flow transparent and sweet, spreading life and health forever. May the water be welcomed, cared for and treated well in your homes. May there be enough for everyone for the rest of times.

This Manual tells you how and why it is vital to treat and properly dispose of the wastewater that you generate in your house so that it ensures environmental health, does not contaminate and, if possible, be reused and recycled.

In our homes we generate two types of wastewater: **graywater** from sinks, showers and washing sinks, and **blackwater** from the toilets. These waters, once they leave your houses, must be treated to reduce contamination. This can be done with different systems, and then this water must be reused and recycled back to the environment in three possible ways.

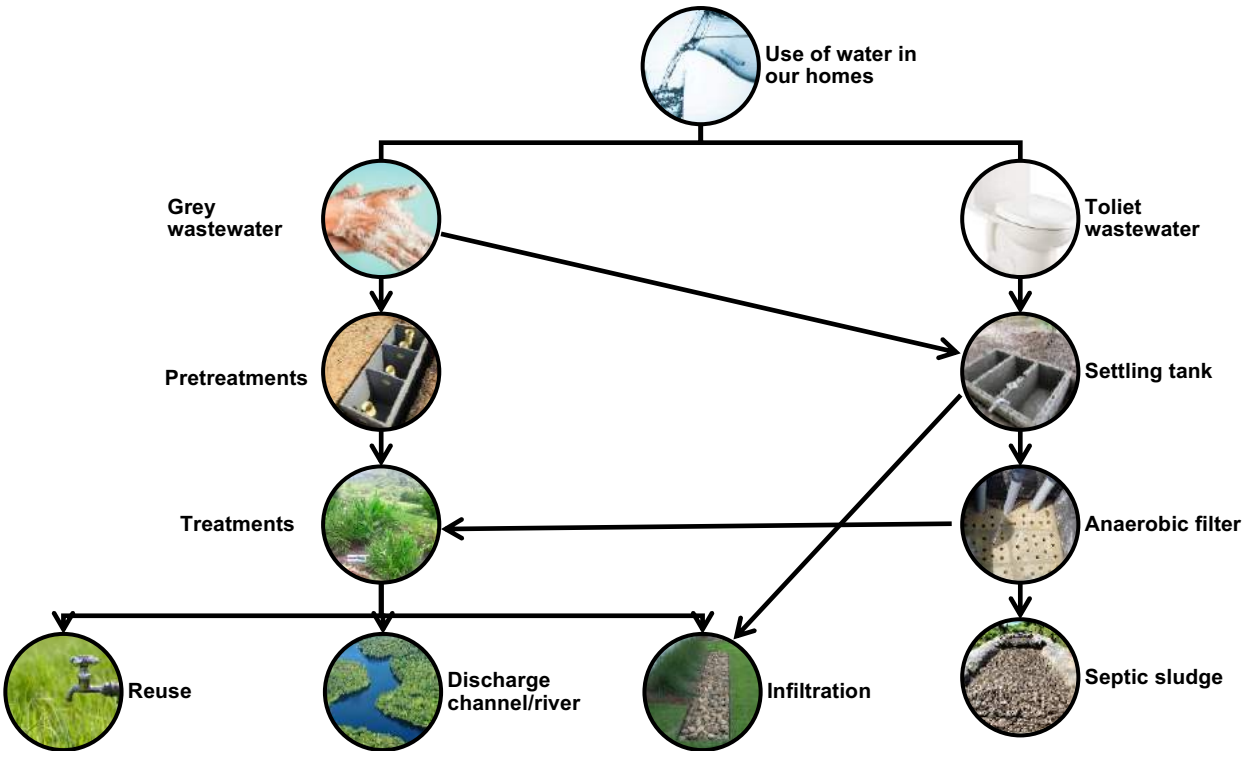

Figure 1. Treatments and different ways of disposal for domestic wastewater.

This Manual describes FIVE different systems schemes so that users can choose the most appropriate method of disposing of the wastewater they generate:

System 1: Individual wastewater treatment plants.
System 2: Composting latrines.
System 3: Waterless system with Urine Diversion.
System 4: Upflow Anaerobic Filter.
System 5: Constructed Wetlands

Although you will find the most logical combinations here, please note that there are additional technologies available and these methods can be used in different combinations. The designer in charge of your house system should try to minimize redundancy, optimize the existing infrastructure and make use of local resources.

This Manual will allow you to understand and work with the concepts of some system parts, which will allow you to select a complete system and interactively link appropriate technologies; It is important to know the specific advantages and disadvantages of each one of them. The systems presented are those authorized by the Code of Hydraulic and Sanitary Installations in Buildings and by the Ministry of Health of Costa Rica.

GLOSSARY

Aerobic: Describes biological processes that occur in the presence of oxygen

Anaerobic: The degradation and stabilization of organic compounds by microorganisms in the absence of oxygen, leading to production of biogas.

Black Water: wastewater originated in toilets.

Composting: The process by which biodegradable components are biologically decomposed by microorganisms (mainly bacteria and fungi) under controlled aerobic conditions

Ecological Sanitation (EcoSan): An approach that aims to safely recycle nutrients, water and/or energy contained in excreta and wastewater in such a way that the use of non-renewable resources is minimized. (Syn.: Resources-Oriented Sanitation).

Environmental Sanitation: Interventions that reduce people's exposure to disease by providing a clean environment in which to live, and with measures to break the cycle of disease. This usually includes hygienic management of human and animal excreta, solid waste, wastewater, and stormwater; the control of disease vectors; and the provision of washing facilities for personal and domestic hygiene. Environmental Sanitation involves both behaviors and facilities that work together to form a hygienic environment.

Influent: The general name for the liquid that enters into a system or process (e.g., wastewater).

Lime: The common name for calcium oxide (quicklime, CaO) or calcium hydroxide (slaked or hydrated lime, $Ca(OH)_2$). It is a white, caustic and alkaline powder produced by heating limestone. Slaked lime is less caustic than quicklime and is widely used in water/wastewater treatment and construction.

Reuse: Use of recycled water.

Operation and Maintenance (O&M): Routine or periodic tasks required to keep a process or system functioning according to performance requirements and to prevent delays, repairs or downtime.

Septic: Describes the conditions under which putrefaction and anaerobic digestion take place.

Sludge: is the residual semi-solid material that is produced as a by-product by sewage systems, such as septic tanks.

Sanitation: The means of safely collecting and hygienically disposing of excreta and liquid wastes for the protection of public health and the preservation of the quality of public water bodies and, more generally, of the environment

Wastewater: Used water from any combination of domestic, industrial, commercial or agricultural activities, surface runoff/stormwater, and any sewer inflow/infiltration. This includes grey wastewater and toilet blackwater.

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1 // INDIVIDUAL WASTEWATER TREATMENT PLANTS

1.1. DESCRIPTION

It is possible to install individual Wastewater Treatment Plants (WWTP). The design of these systems is adjusted to the necessities of all clients, since there are many different options depending on the amount of investment and the kind of system each person wants. Depending on the system that is installed this will vary its maintenance tasks, as well as its advantages and disadvantages. Below you will find a list of individual system providers in Costa Rica; approval of the installation of these systems requires technical-scientific support.

1.1.1. BIONEST^{MD}:

This system offers high performance water purification with simple, efficient and durable technology. It comes with a warranty and after-sale service. This system is conformed by a pretreatment which is a standard sedimentation tank, followed by a biological treatment process. The biological treatment uses micro-organisms which degrade pollutants. It is the same process which occurs over time in the ground, as in a leaching field, but within a controlled environment. These micro-organisms are fixed on a media manufactured by Bionest^{MD} and placed inside a reactor, providing a controlled environment for the elimination of pollutants.

The treated effluent is then discharged on a water body, or an additional method of purification, can be installed for reusing in irrigation.

ADVANTAGES AND DISADVANTAGES

+ Each component is inspected within a maintenance agreement, to ensure proper operation of the system

+ Long useful life.

+ High reduction of polluting matter.

+ 1 year warranty of all components and 20 years warranty of the Bionest^{MD} media.

+ Resistant to hydraulic shocks.

- Requires constant electrical consumption for the pumps.
- Requires expert supervision. In installation

APPROXIMATE COSTS*

Installation: $5100 - $5800

Maintenance: $125/year (Includes an annual visit of an expert).

DIAGRAM

Figure 2. Bionest® system

1.1.2. HIDROTECO:

Hidroteco offers a Wastewater treatment plant, the I-500-PLT, which is an alternative to the traditional septic tank. This plant can treat 500 gallons per day, and it's easy to operate and maintain. It is made of a polyethelene material to offer a seamless tank with maximum durability. This plant is locally supported by trained and certified distributors.

The system works aerobically, so it uses a blower to maintain oxygen inside of the system. It also has a clarifier in the second tank to allow for sedimentation of the solids before the water passes through additional filtration, to eliminate pathogens. After this treatment, water can be reused for irrigation.

ADVANTAGES AND DISADVANTAGES

+ High reduction of polluting matter.

+ 1 year warranty of all components.

+ Resistant to hydraulic shocks.

− Requires constant electrical consumption for the pump and the blower.

− Requires expert supervision of installation and maintenance.

APPROXIMATE COSTS*

Installation: $6600-67000 (Includes 1 gallon of Biojet 7® which is an organic solution that helps accelerate the degradation of fats, oils, greases, proteins and organic material)

Maintenance: $130/year (Includes an annual visit of an expert).

DIAGRAM

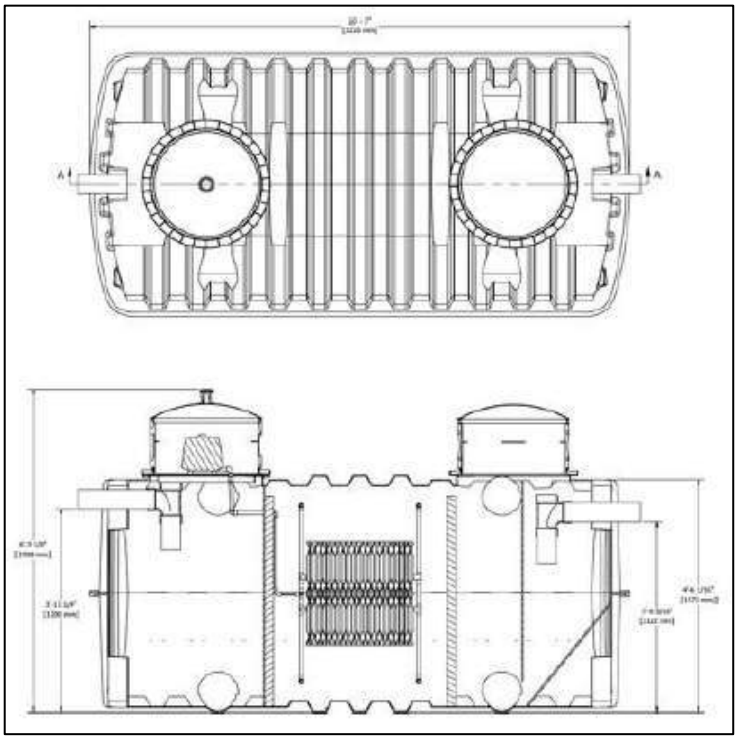

Figure 3. The *Jet / 500* plant of Hidroteco

1.1.3. ELOY OXYPLANTA®:

The OXYPLANTA® is an aerobic system with great efficiency to filter domestic wastewater. It is conformed by three different tanks: the primary settling tank that separates solids and helps eliminate oils and greases, the biological reactor witch uses oxygen and microorganism to treat the water, this reactor has a filter made with OXYBEE® which are little structures made with recycled polypropylene. And finally, a secondary settling tank to finish with the filtration. It is possible to install a fourth tank to use as a storage tank with a little pump, to use for irrigation water.

ADVANTAGES AND DISADVANTAGES

+ Eloy is a Belgium enterprise with 40 years of experience in wastewater plants.

+ High and efficient reduction of polluting matter.

+ Low production of sludge.

+ 1 year of warranty for electromechanical components.

− Constant electrical consumption for the blower.

− Requires expert supervision of installation.

− Uses three or four tanks which make it bigger than other plants, needs large space for installation.

APPROXIMATE COSTS*

Installation: $6000 - $6400

Maintenance: $150/year + the cost of the parts that need to be replaced

DIAGRAM

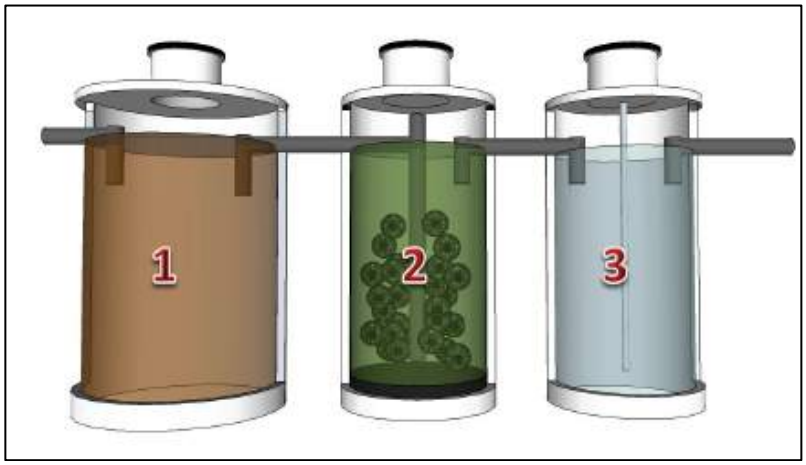

Figure 4. The OXYPLANTA®

1.1.4. TIM-AT8®:

Tim-AT's treatment plants are fabricated with high density polypropylene with a removable lid resistant to UV rays. This wastewater treatment plant uses an anoxic reaction and an Upflow Sludge Blanket Filtration (USBF), and it uses a blower to introduce oxygen to the reaction. It is a compact system because all of the stages of the treatment happen in the same tank. The sludge generated in this system is relatively high so they have to be removed every 12 months.

ADVANTAGES AND DISADVANTAGES

+ Compact system, limited space to install.

+ High reduction of polluting matter.

+ Resistant to hydraulic shocks, ability to operate with +-10% of its capacity.

− Requires approval of the Ministry of Health for its importation and installation.

− Constant electrical consumption for the blower.

− Requires expert supervision of installation.

− It must be imported from Mexico, there are no official distributors in Costa Rica.

APPROXIMATE COSTS*

Installation: $2800 + costs of importation + taxes

Maintenance: $150/year

DIAGRAM

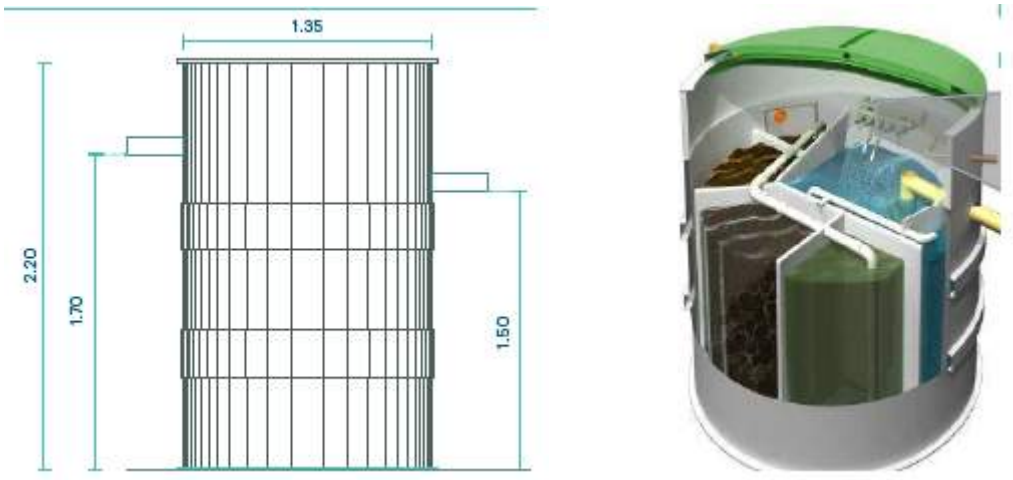

Figure 5. TIM-AT8 treatment plant

1.2. SUPPLIERS IN COSTA RICA

Bionest: www.bionest-tech.com / Tel: (506) 2288 4358

Hidroteco: www.hidrotecocr.com / Tel: (506) 2203-2608

Depuragua: www.depuragua.com / Tel: (506) 4081-4900

Gaia: www.gaiacr.com / Tel: (506) 2430-5834

Eloy: http://www.eloyamericalatina.com/ / Tel: (506) 8712-3319

**TIM: https://thinktim.mx/residencial/ -(imported)

2 // COMPOSTING LATRINES

DESCRIPTION

In compost latrines, a composting process is carried out with the mixture of feces and urine. Composting refers to the process by which biodegradable components are biologically decomposed under aerobic conditions, with oxygen, by bacteria and fungi. In a compost chamber, excreta and organic materials are converted into compost, which is a stable and harmless material that can be safely managed and used to enrich the soil. Other organisms may also participate, such as Red Californian Worms, which help with the transport of oxygen and moisture through the composted material.

A composting chamber can be designed in various configurations and constructed above or below ground, indoors or with a separate superstructure. This system usually requires four main parts:

- A reactor, known as a storage chamber.
- A ventilation unit to provide oxygen and allows gases to escape.
- A leachate collection system.
- A door to remove the mature product.

These latrines must have the appropriate exit of liquids through a lower point and thus lead them to where they can be treated. An appropriate lateral ventilation system must be designed to allow a permanent entry of air flow, there must be an entrance from both sides of the chamber allowing an opening or closing of the air flow. There must be a gate for the handling of the compost, this access will be used also to introduce the material that provides volume and organic load, as well as to carry out the operational actions required by the composting process (which includes stirring and moving the mass in the process of degradation). This gate must be hermetic.

The separation of the solid material from the liquid must be achieved by a perforated or porous mezzanine. Therefore, there must be an appropriate outlet for liquids through a lower point, that outlet must have a PVC joint to interconnect with a pipe, made of the same material and with a diameter not less than 25 mm.

In composting latrines, it is necessary to add light wood sawdust in order to mix it into the mixture and help aeration and contribute with a carbon source necessary to achieve a correct balance.

The final product of compost is a material that has the odor of "wet soil", rich in elements that contribute to the characteristics of natural soil by improving its physical conditions and availability of nutrient elements for plants. The effluent, also rich in nutrients, is a natural organic fertilizer that can also be applied to the soil and plants.

If you choose to install this system, greywater must be treated separately.

ADVANTAGES AND DISADVANTAGES

+ Significant reduction in pathogens.

+ Compost can be used as a soil conditioner.

+ No real problems with flies or odors if used and maintained correctly.

+ Organic solid waste can be managed concurrently.

+ Long service life.

+ Low operating costs if self-emptied.

- Requires well-trained user or service personnel for monitoring and maintenance.

- Compost might require further treatment before use.

- Leachate requires treatment and/or appropriate discharge.

- Requires expert design and construction.

- May require some specialized parts and electricity.

- Requires constant source of organics.

- Manual removal of compost is required.

OPERATION & MAINTENANCE

The addition of sawdust is recommended after each use, this serves as an absorbent material, prevents unpleasant odors and the attraction of flies. It is recommended to have at least one transparent observation window, to periodically check the internal part of the chamber. If it is necessary to oxygenate the compost mix, the user must use a tool similar to a rake and protective gloves.

Depending on the system design, the composting chamber should be emptied every year. Only fully mature compost should be removed. A squeeze test can be used, which requires the user to squeeze a portion of compost by hand. The compost shouldn't crumble nor feel dry, nor should it feel like a wet sponge. Over time, salt or other solids will settle into the tank or leachate collection system, which can be dissolved with hot water and/ or be cleaned by scraping.

SUPPLIERS IN COSTA RICA

Fibromuebles: www.fibromuebles.com / **Tel:** (506) 2288-6338

APPROXIMATE COSTS*

Construction: $850 - $1350

Maintenance: $40/month for sawdust.

DIAGRAM

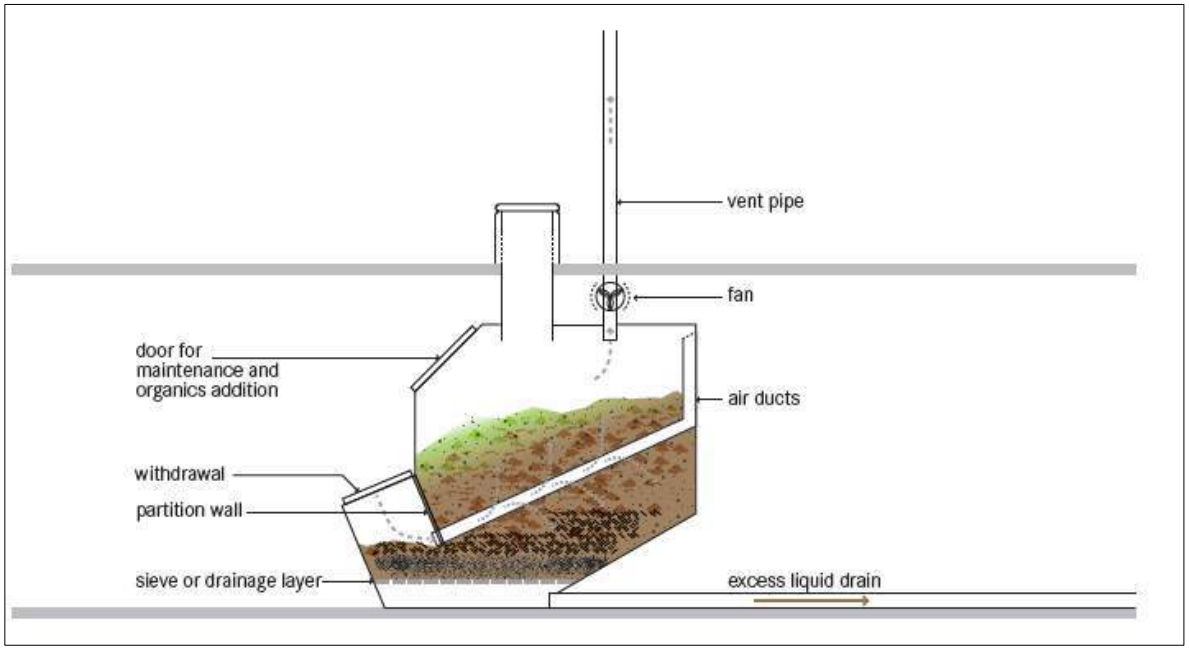

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Figure 6. Composting chamber.

3 // WATERLESS SYSTEM WITH URINE DIVERSION

3.1. DESCRIPTION

This system is designed to separate urine and feces, to allow the feces to dehydrate and recover the urine for a beneficial use. The dry toilet is sanitary because it satisfies the need to deal with excreta in a healthy way, it is ecological because it takes advantage of natural biological cycles to transform organic matter - excreta - into a harmless product ready to nourish the soil, and it is dry because it does not use water, so there is no contamination.

In Costa Rica, according to current regulations, a dry toilet can be installed only with separation of urine and feces. There are two user interface technologies for this system: a Urine Diverting Dry Toilet (UDDT) or a urinal. It is recommended to install both of them, so that women use de UDDT and men the urinal.

This toilet must be placed on a concrete structure which will have at least two continuous chambers for the storage and dehydration of feces. The volume of each chamber must be at least 0.6 m^3. There can be a maximum of six inhabitants per chamber.

Human excreta is treated by an aerobic process, that is, with oxygen. Therefore, environmental conditions are necessary to ensure that the organic matter deposited within the chambers remains oxygenated and balanced. When stools are stored in chambers, they should be kept as dry as possible to promote dehydration and sanitation. With every use excreta must be covered with a mixture rich in carbon, thus transforming the excrement into a compost free of microbes. This also minimizes odors and establishes a barrier between feces and potential vectors (like flies).

The excreta alone do not have the ability to transform, it needs other materials to feed the microorganisms that transform them. We must always cover the excreta when we use the toilet, so we should never miss a pot with carbon mixture inside the bathroom. The secret to avoid unpleasant odors is to cover with a carbon-rich mixture anything suspected of unpleasant odors. You can use lime, sawdust, rice husk, ash, dry earth or a mixture of these.

The two continuous confinements made of concrete are necessary so they can be alternated annually. The chambers must have a ventilation tube that protrudes above the roof of the dry toilet system. The organic matter produced by dry toilets and composters should not be used to fertilize vegetables or other plants that are consumed fresh.

A separate system for the treatment and disposal of graywater must be installed. The minimum retreat that must be respected with respect to boundaries is 5 meters.

3.2. ADVANTAGES AND DISADVANTAGES

+ Because double vaults are used alternately, their life is virtually unlimited.

+ Significant reduction in pathogens.

+ Potential for use of dried feces as soil conditioner.

+ No real problems with flies or odors if used and maintained correctly (i.e., kept dry).

+ Can be built and repaired with locally available materials.

+ Suitable for rocky and/or flood prone areas or where the groundwater table is high.

+ Low (but variable) capital costs depending on materials; no or low operating costs if self-emptied.

+ Does not uses water.

+Urine can be used as a fertilizer.

– Requires training and acceptance to be used correctly.

– Requires constant source of cover material.

– Manual removal of dried feces is required.

– Education for users is necessary.

OPERATION & MAINTENANCE

The seating or standing surface should be kept clean and dry to prevent the transmission of pathogens or diseases and to reduce odors. There are no mechanical parts so Dry Toilets require minimal repairs

Handling and treating the urine:

All urine must be collected separately from feces. It should be stored in containers with a capacity of 2 to 5 liters. Once the container is full, it should be stored covered in a cool, dry place for at least six weeks. After this time, a mixture of diluted urine with water in a 1: 3 ratio (1 part urine and 3 parts water) has to be generated.

Table 1. Urine mixture for use as plant fertilizer.

Mixture (L)	Urine (L)	Water (L)
4	1	3
8	2	6
12	3	9
16	4	12
20	5	15

This mixture can be used to irrigate plants, ornamentals or lawns. In the case of crops or trees with fruits, it can only be applied to the lower part of the plants so that it does not come into contact with the food. Urine should not be applied the last month before harvesting.

After some time of storage, a layer of organic sludge and precipitated minerals will form at the bottom of the urine container, so it should be cleaned periodically. Any equipment used to collect, transport, or apply diluted urine (like a watering can) can become clogged over time. Most deposits can be easily removed with hot water and a little vinegar, or in more extreme cases, scraped off by hand.

Handling and treating excreta:

The structure of the toilet must be mobile so it can be located over one of the two chambers. The slab must have a hole on each of the chambers, in which the toilet will be installed, these holes must remain covered when they are not being used.

Each confinement or chamber must be used for a period of one year, after this time, the toilet must be moved to the continuous chamber which will be used for the following year. This has to be done once a year so that the chamber filled with material has enough time to decompose. The decomposition residue resulting from each chamber should be removed after the year of degradation.

Gloves should be used to handle organic matter resulting from decomposition and ensure that it does not touch your skin. This decomposition material should be buried or used as fertilizer, which should be applied to the base of the plants, in the latter case it should be covered with a little soil to avoid runoff due to rainwater.

3.3 SUPPLIERS IN COSTA RICA

Asesores: Finca Agroecológica El Tablazo www.fincaeltablazo.com

WCEco Costa Rica: http://wceco.mx/ / Tel: (506) 8837 0971 ó 8705 9424

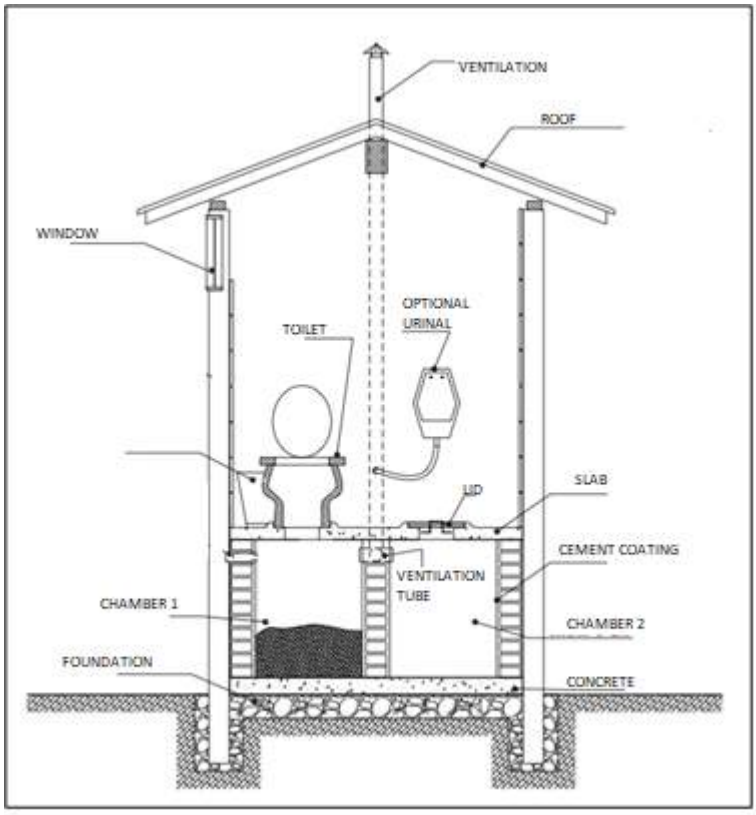
AguaOff: www.aguaoff.com / Tel: (506) 2560-5454

3.4 APPROXIMATE COSTS*

Construction: $1600 - $2100

Maintenance: $40/month

3.5 DIAGRAM



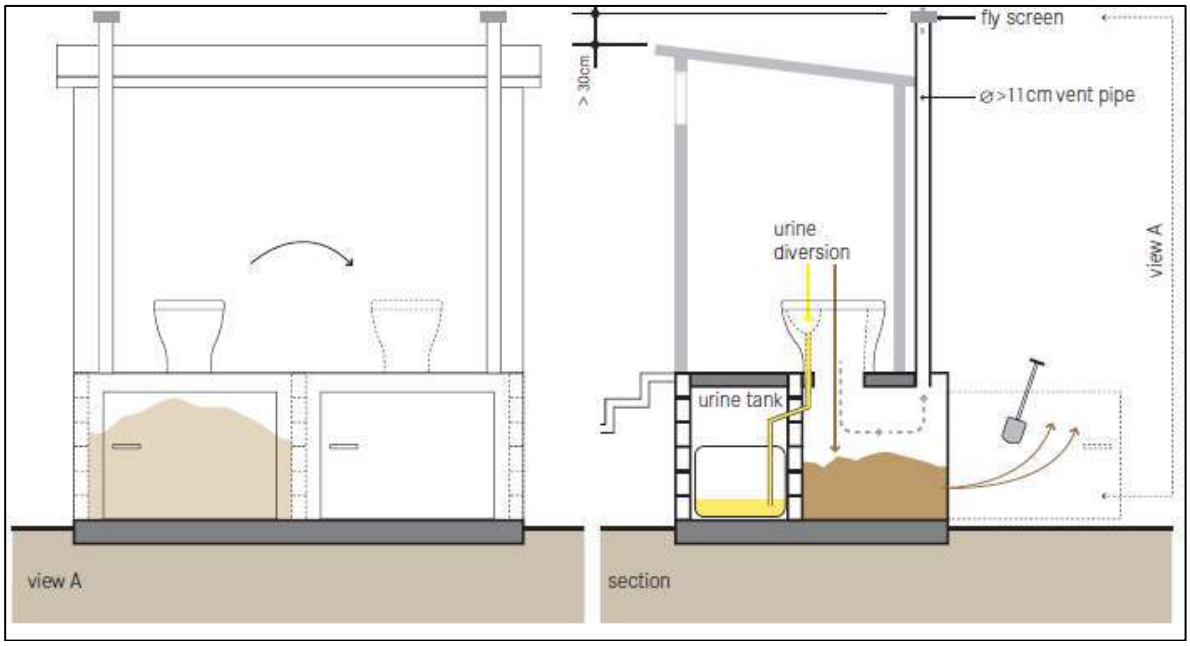


Figure 8. Dry toilet schemes

4 // UAF – UPFLOW ANAEROBIC FILTER

4.1. DESCRIPTION

An Upflow Anaerobic Filter (FAFA in Spanish) is a fixed bed bioreactor better known as a filter. When the wastewater flows through this filter which is full of bacteria, it is purified, since the particles are retained in the filter and the polluting matter is degraded. This system is always installed after a settling tank, and one or more filter chambers can be installed.

Commonly used filter materials include gravel, broken stones, charcoal, or designed pieces of plastic. In an UAF, water enters from below and is collected above. The stones or filter media are supported by a "floor" or false base. This filter provides a large surface area for the bacterial mass, so there is a greater contact between the organic matter and the active biomass that effectively degrades it. This filter is anaerobic, in the absence of oxygen, so it must be hermetic. As this system is installed underground, users do not come into contact with the influent or effluent.

4.2. ADVANTAGES AND DISADVANTAGES

+ No electrical energy is required.
+ Low operating costs.
+ Long service life.
+ High reduction of BOD and solids.
+ Low sludge production; the sludge is stabilized.
+ Moderate area requirement (can be built underground).

− Requires expert design and construction.
− Low reduction of pathogens and nutrients.
− Effluent and sludge require further treatment and/or appropriate discharge.
− Risk of clogging, depending on pre- and primary treatment.
− Removing and cleaning the clogged filter media is cumbersome.
− Long time before it stabilized.

4.3. OPERATION & MAINTENANCE

When starting the operation of the UAF it is recommended to add active bacteria to ensure proper operation. This filter must periodically be checked by using the vertical tube entering the system. It is necessary to understand that over time that solids will clog the filter pores. Also, the growing mass of bacteria will be too thick and will break down and clog the pores. This filter should be cleaned when its efficiency drops, and there should be a maximum period of one year between cleanings.

Filters are cleaned by operating the system in reverse mode to unblock the accumulated biomass and the particles, using a downward flow of water to drag all the accumulated solids. Water is discharged a maximum of three times over the filter during this process. Do not leave the filter completely clean as there must be remaining bacteria attached. They can also be designed in such a way that the filter is removable and easily cleaned outside of the unit.

4.4. SUPPLIERS IN COSTA RICA

Grupo MT: www.muchotanque.com / **Tel:** (506) 2573-8181

Fibromuebles: https://www.fibromuebles.com / Tel: (506) 2288-6338

4.5. APPROXIMATE COSTS*

Construction: $1700 - $2200

Maintenance: $100/year.

4.6. DIAGRAM

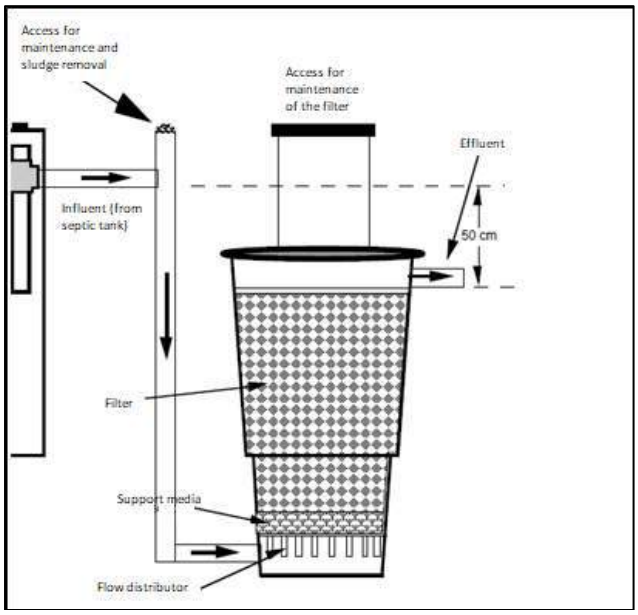


Figure 9. Diagram of an UAF.

5 // CONSTRUCTED WETLANDS

5.1. DESCRIPTION

Constructed wetlands (CW) are units for the treatment of grey wastewater, or for the outgoing waters of an upflow anaerobic filter. They are used as an additional treatment step mainly to remove nutrients, like nitrogen and phosphorous. When CW are used for treating only greywater, greasy elements have to be previously removed, so a pretreatment has to be installed.

CW consists of a large channel filled with stones, gravel and sand where aquatic vegetation is planted. As the wastewater flows horizontally through the channel, the material contained filters out particles, and microorganisms degrade the organic matter. These units are very simple and function as filters given the horizontal flow of water through granular filter material and as biological units, given the participation of plants when extracting organic matter and nutrients. The treated water obtained at the end of this process is not 100% purified, but it will have very good quality and can be reused in activities, such as irrigation, but not for human consumption.

Any plant with wide and deep roots that can grow in the nutrient-rich aquatic environment is appropriate. *Phragmites australis*, *Heliconias or Cyperus papyrus are common* choices because they form horizontal rhizomes that penetrate the entire depth of the filter.

When they are used to treat greywater, a pre-treatment must be carried out, at least two units are required to eliminate greases and solids, this will allow more efficient results by regulating the speed of the water flow and preventing particles from entering the CW. In each pretreatment unit, gases with offensive odors will be produced, so they must be conducted to points away from habitation, using pipes. It should also be ensured that no trees grow in the nearby area, to prevent roots damaging or entering the waterproof coating.

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5.2. ADVANTAGES AND DISADVANTAGES

+ Aesthetically pleasing, naturally beautiful.

+ High reduction of BOD, suspended solids and pathogens.

+ Does not have the mosquito problems of the Free-Water Surface Constructed Wetland.

+ Very simple system, where the water flows by gravity and can work without the need for pumping equipment. No electrical energy is required.

+ Low operating costs.

– Risk of clogging, depending on pre- and primary treatment
– Long start-up time to work at full capacity
– Requires expert design and construction

5.3. OPERATION & MAINTENANCE

Regular maintenance should ensure that the water does not flow back due to fallen branches or garbage blocking the outlet pipe of the CW. It may be necessary to trim vegetation periodically so that it does not become too dense. It is also necessary to check the distribution channel or inlet pipe and remove the particles settled in that channel. This has to be done at least once a month.

Plants that are sown must be cut the first time, one year after their sowing, and then, at least, every six months. It is very important to carry out a periodic cleaning of the surface of the filter beds, especially after cutting or trimming the plants to avoid saturation of the beds with the decomposition of the organic products.

Over time, rocks and gravel will become clogged with solids and a layer of bacteria will form. Filter material may require a replacement 10-15 years after staring its operation. Constant maintenance of the pretreatment units is also required, at least once a week, floating fats and solids deposited on the bottom must be removed using gloves and a strainer.

6.4. SUPPLIERS IN COSTA RICA

ACEPESA: www.acepesa.com / Tel: (506) 2280-6291

GAIA: www.gaiacr.com / Tel: (506) 2430-5834

6.5. APPROXIMATE COSTS*

Construction: $1500 - $2000

Mantainance: time for cleaning and maintenance of plants.

6.6. DIAGRAM

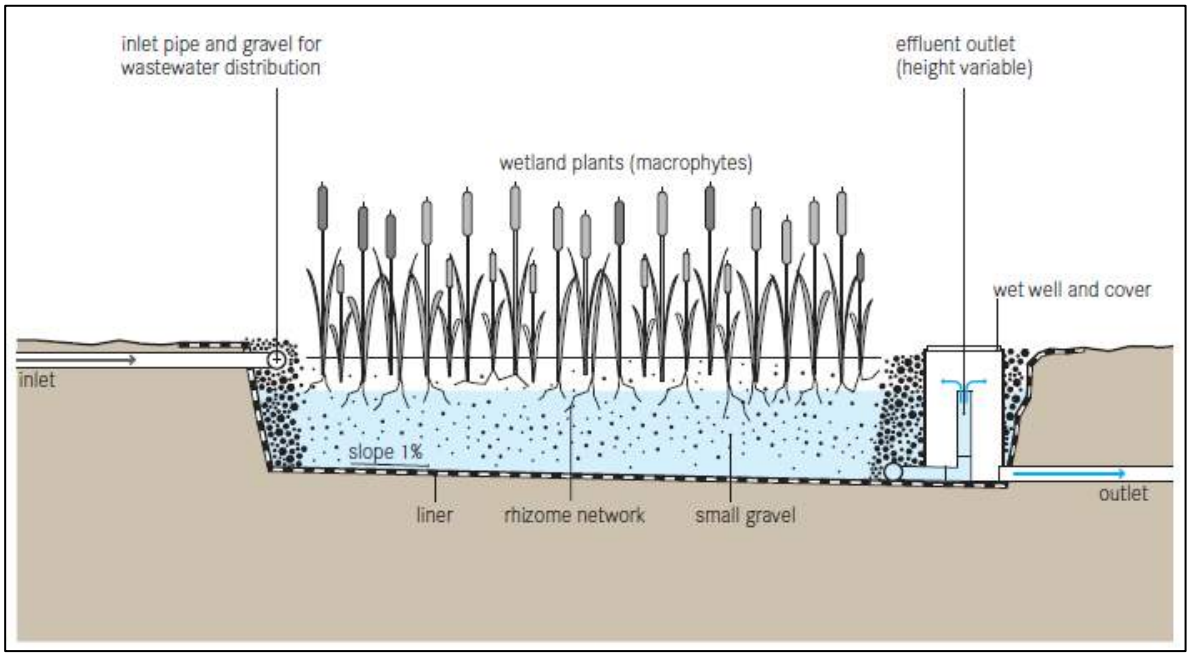


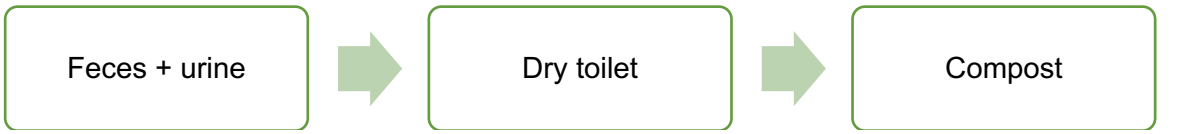
Figure 10. Diagram of a constructed wetland

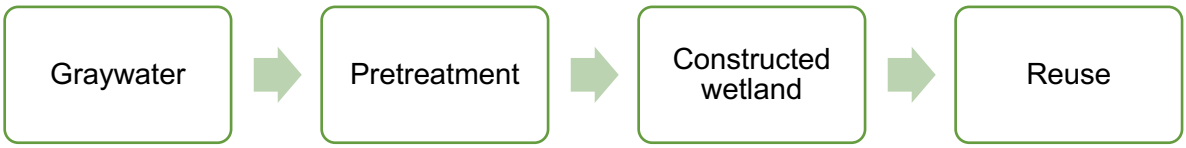
CONCLUSIONS

After checking the different systems and their advantages and disadvantages, you can now select the best scheme for your home. Here are some final tips, however, the different settings are not exhaustive, be creative and use your imagination!

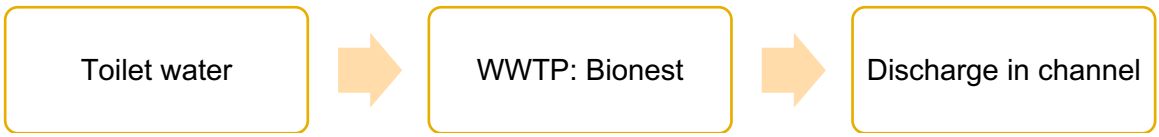
Scheme N°1:

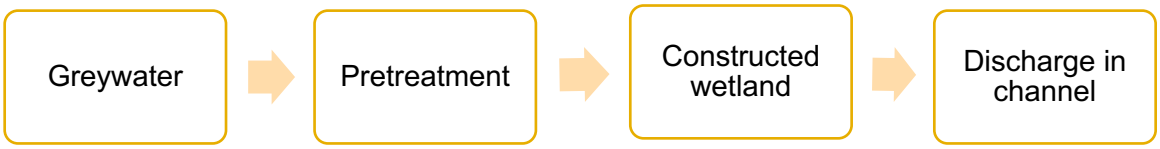
Scheme N°2:





Scheme N°3:





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**Costs indicated in this Manual depend on the dimensions of the systems, the terrain conditions, the materials selected for the construction and the number of users of the system; they may vary significantly.*