HOME BIOFILTERS

Biological filters to remove greywater nutrients

IDEASS NICARAGUA

Innovation for Development and South-South Cooperation

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Presentation

Text written by Héctor Delgado and William Pérez

Incorrect disposal of greywater is common in neighbourhoods that do not have a sanitary sewer system, producing a deterioration of environmental conditions: puddles in the streets and a proliferation of carriers of diseases that usually attack the most vulnerable members of the population.

Greywater represents 80% of the total wastewater generated in homes, the product of many everyday activities including personal hygiene, household cleaning, and the washing of dishes, cooking utensils and clothes.

An alternative form of greywater management is the biological filter, which uses natural processes to purify water. Biological filters have proven to be an appropriate technology for the treatment of domestic greywater, ensuring the effective removal of 95% of organic matter. The quality of water found in effluent is optimal for use as irrigation, and can be channelled into a body of surface water or used to recharge groundwater aquifers through infiltration. Cleaning up the water helps to minimize the negative environmental impacts caused by the disposal of greywater in soils, lakes and rivers.

Many technological advances in the treatment of waste water are taken from nature itself, and the action of biological agents in natural processes keeps different ecosystems in balance.

In Nicaragua, the Centro de Investigación y Estudios en Medio Ambiente (CIEMA) and the BIOMASS Project promoted by the National University of Engineering, with Austrian cooperation, experimented in 1996 the construction of the first biofilters for a group of houses on the outskirts of the cities of Masaya and Leon. The first Biofilter system was a pilot project for a condominium in the city of Masaya to investigate the technical and economic feasibility of applying this technology in the tropics of Central America. To date this technology has spread to different municipalities of the country and the Central American region.

Currently, the Centro de Estudios y Promoción para el Habitar, through the project Integrated Initiative for Sustainable Urban Environment (ISSUE-2), funded by the Dutch government, promotes biofiltration technology on a domestic scale for the treatment of household greywater, based on experiences in Costa Rica, as an alternative form of sanitation aimed primarily at low-income families who reside in neighbourhoods lacking sewerage services.

Domestic biofilter technology won first prize in the 2009 edition of the Human Development Innovation Competition, organized by the Nicaraguan Council of Science and Technology (CONICYT), in collaboration with major international and national organizations operating in Nicaragua.

What problem does it solve?

In Latin American and Caribbean countries, 124 million people lack proper sanitation facilities and hygiene conditions are poor. Over 75% of sewage is dumped into the environment without treatment, contaminating the very water sources that are used for drinking (UNICEF 2008).

Sanitation is a means to expand human development. The problem of sewage and greywater is linked to sanitary conditions and there is a lack of sanitation for an overwhelming number of people in developing countries. Nearly one in every two people in developing countries lack access to improved sanitation - two and a half times the deficit for access to clean water. (Source: Human Development Report 2006, UNDP).

The lack of adequate sanitation is associated with various diseases like diarrhoea, which often cause rapid malnutrition and pneumonia. These diseases cause an overwhelming annual number of deaths, especially among children. Some of the most important benefits of sanitation include improved public health, a considerable decrease in diseases spread by water, and prevention of the premature death of millions of human beings.

The sanitation gap between developed and developing countries is an example of human development inequality. Due to inadequate technological capacity and financial resources, to address problems of sanitation developing countries need alternative and innovative technologies, consistent with the endemic conditions of their country.

Domestic biofilters as an alternative form of sanitation

In this context, domestic biofilters represent an alternative form of sanitation, and an environmentally friendly solution for the treatment of greywater. By reducing the negative impacts caused by the incorrect disposal of greywater and improving the quality of the water before being returned to nature, the living standards of people are improved and the natural beauty of the environment preserved.

By using home biofilters for the treatment of greywater, water can be reused (recycled), which is also beneficial from the financial standpoint. The resulting water from biofilter effluent, depending on the quality present at the end of treatment, can be used for other activities within the home, reducing potable water consumption by up to 20%. Bearing in mind that 80% of household water can be treated by this technology, this high volume of water is not sent to municipal treatment systems, reducing sewage treatment costs.

The main tools to build home biofilters can be found in homes and are readily available in the market. Biofilters are mainly built with local materials that are readily available, thus with a low cost; they are simple to make and require no skilled labour, so that with just a little technical monitoring families make them for themselves and adapt them to their needs. Since they can also be used for planting ornamental plants, they can be turned into a scenic garden outside the houses where they are located.

Biofilters have no maintenance costs. Routine maintenance is carried out by the same families that adopt the biofilter system. The system works entirely through the effects of gravity, so no electricity is required.

The difference between traditional and biofilter technologies is mainly one of environmental cost. Biofilters are more environmentally friendly because they reduce many of the pathogens to be found in the water, returning it to nature to recharge aquifers. In conventional technologies, the water that infiltrates into the soil still contains a large amount of organic matter and other pollutants that produce negative impacts on the soil and aquifers.


Photo 1


Photo 2

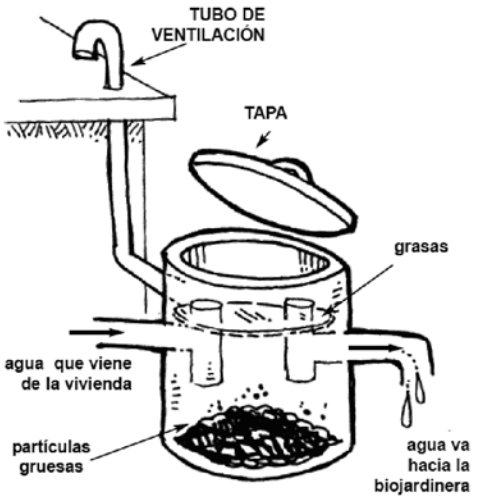

Photo 3


Photo 4

Domestic Biofilters in practice

A biofilter is designed to treat greywater by biofiltration, which combines mechanical retention through filtering material and biological transformation of the pollutants in the water to be treated, eliminating a significant amount of pollutants before they reach the groundwater, river or natural wetland. The system can be designed for a single house or groups of houses. The size of the system varies according to the volume of water treated.

Greywater contains nitrates, phosphates, soap, salt, bacteria, foams, food particles, organic matter, suspended solids, perfumes and dyes. Greywater originates from households, schools and all places where water is used for cleaning purposes, excluding excreta. It is the product of laundries, bathrooms, sinks and other household uses. Home Biofilters are a sustainable way of removing pollutants from greywater. Below are details of the operations and processes involved in biofilter water treatment.



TRATAMIENTO PRIMARIO

Primary treatment or pre-treatment

Pre-treatment takes place before the biofilter comes into operation, and involves separating the free floating material and sedimentable matarial. The containers are usually plastic tanks, used to separate fat, their size depending on the volume of greywater to be treated. One or more containers can be used to improve removal. Sedimentable materials sink to the bottom of the tank due to differences in specific gravities. In this way fats and detergents are separated and free floating material comes to the top of the tank.

The systems promoted usually have two fat separator tanks to ensure removal of as much material as possible. This step is essential if the system is to function properly, since it prevents larger particles from reaching the biofilter. Routine maintenance for this process involves the removal of solids and fat stuck to the tanks. Maintenance frequency depends on the volumes of water discharged and the number of solids present; however, it should be done at least once or twice a week.

Biological treatment (biofilters)

A biofilter consists of a trench, dug by hand and waterproofed walls, with a filter bed made of gravel, volcanic rock or other material having similar characteristics. Within the substrate a biological process takes place triggered by bacteria that are found naturally within it and in the roots of plants, which break down nutrients in both the water and the soil.

Photo 5 | Photo 6 | Photo 7 | Photo 8

The residual water is in contact with aerobic and anaerobic zones, usually for a few days, giving rise to microbiological and physicochemical degradation processes. Aerobic zones are provided by plant roots, injecting oxygen by natural processes; the anaerobic zones are those away from the roots of plants and which generate conditions conducive to the development of bacterial film. Biofilter maintenance takes place sporadically, depending on the frequency of fat separator tank maintenance or pre-treatment and involves washing the filtering material found in the biofilter's first two meters of length.

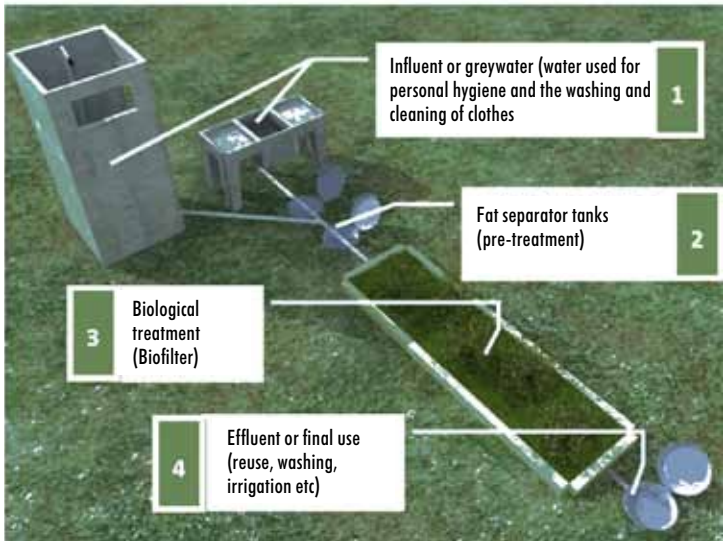
The filter bed provides a base for growing water plants or microphytes. Because home biofilters are located close to houses, we recommend sowing ornamental plants. Recommended plants for this type of system include:

- Canna X generalis (bandera, platanilla) - **Photo 1**
- Musa laterita (banano de bronce) - **Photo 2**
- Hedychium coronarium (lirio blanco) - **Photo 3**
- Alpinia purpurata (ginger) - **Photo 4**
- Heliconia psittacorum (avecilla) - **Photo 5**
- Heliconia wagneriana (platanillo) - **Photo 6**
- Heliconia rostrata (platanillo) - **Photo 7**
- Costus speciosus (caña agria) - **Photo 8**

Water use (disposal or utilization)

A decision has to be made on the final use of the water treated in the biofilter system. Since this water is clear, not turbid and free of much of the original organic material, it can be reused for irrigation, washing or cleaning. This water can also be used to recharge groundwater through infiltration. Biofilters have been proved to remove the following:

Source: S. Chávez y O. Guevara, Evaluación del sistema de tratamiento de aguas residuales domiciliares por biofiltros de flujo horizontal, del programa ISSUE 2 en barrios del distrito V de Managua, 2010



Biofilter treatment system (Source: HABITAR)

Average percentage of pollutants removed by home biofilters according to parameter analysed

Parameter analysed	Pollutant removal percentage (%)
Fats and oils	92-96
BOD (mg / L)	85-95
COD5 (Mg/L)	95-95
NO3 (mg/L)	90
Total Phosphates	85
S. Solids Total (mg/L)	90
Sedimentable solids (mg/L)	95
SAAM (mg/L)	80
Fats and Oils	93

Step 1 | Step 2 | Step 3 | Step 4

Stages in the implementation of a Biofilter

Design of a home biofilter

To calculate the size of a home biofilter, you need to consider:

- The number of people living in the houses
- The estimated amount of water that these people use.

Therefore, size will be based on the average amount of wastewater produced in the homes, which depends on the number of people for whom it is designed times the amount of water per person. To establish the quantity of water used by people, reference can usually be made to data from a country's national water and sewage board.

Size of pre-treatment tank

For pre-treatment to function properly, certain conditions must be taken into account in the design phase, such as:

- Hydraulic retention time for proper sedimentation or settling of particles.
- Retention time for biodigestion.
- Space necessary for the accumulation of matter (defined by three volumes: liquid volume, sludge volume and fat volume).

Size of Biofilter

To decide on the size of the biofilter, the minimum width of the biofilter (B min) and the minimum length of the biofilter (L min) need to be calculated. The width depends on the depth of the biofilter, the slope and hydraulic conductivity of the filtering material. The length depends on the hydraulic load and amount of greywater. The calculation of the minimum length can also be used to decide on the ideal distance for construction.

Validation

Having made a preliminary decision about width and length, it validated by using a series of parameters that have to meet certain technical criteria:

- If the system is smaller that the actual requirements, efficiency will be lower. Experience has shown that the hydraulic retention time for a correctly sized system must be between 3 and 5 days.
- An empirical estimate must be made of the Biological Oxygen Demand 5 (BOD 5) to have an idea of the quality of water in the effluent. Similarly an estimate is made of the organic load and fecal coliform concentration in the effluent. Since the characteristics of domestic water are generally consistent, data can be used from studies and trials carried out in different regions.

Step 5 | Step 6 | Step 7 | Step 8

Construction stages

The stages in the construction of a biofilter are as follows: place stakes and mark reference levels; excavate hole and level out the bottom; take and verify measurements; place plastic and sacks; prepare PVC pipes; place materials

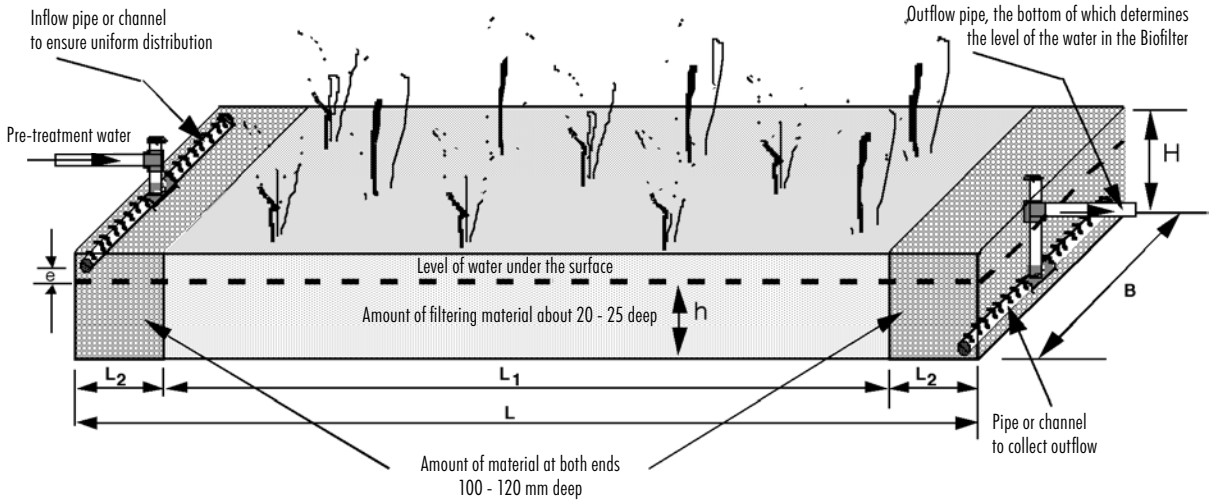
After a pilot biofilter has been built, it is checked and monitored to make sure the system is working efficiently, taking influent and effluent water samples to measure pollution parameters such as BOD (Biological Oxygen Demand), nitrates and phosphates.

The efficiency of these systems depends to a large extent on maintenance, which is carried out at different stages. The process of monitoring and taking samples can be performed by certified laboratories or universities, which is recommended especially for pilot projects and initial studies of the systems.

Steps in the construction of a home biofilter for the treatment of greywater.

Step 1- Reference levels are established
Step 2 - Excavation and conformation
Step 3 - Trench is waterproofed with plastic (Plastic of 1.44 mm minimum diameter)
Step 4 - Sacks are put into position to protect the plastic.
Step 5 - Inflow and outflow channels or pipes are prepared and put into position.
Step 6 - Installation of pre-treatment tank
Step 7 - Biofilter is filled with filtering material
Step 8 - Finishing touches are applied and it is made ready for planting

Calculating the size of a biofilter



Results

In January 2009, HABITAR began work on alternatives forms of greywater management in Nicaragua in 8 neighbourhoods with high environmental vulnerability, with the support of the Integrated Initiative for Sustainable Urban Environment 2 (ISSUE-2), funded by the Dutch Ministry of Foreign Affairs DGIS through the Dutch agency WASTE.

Based on the experience of the National Engineering University's Biomass Project, which involved the assessment and monitoring of technical parameters over a five year period, biofilter technology was adapted to the environmental conditions of the country.

The implementation of biofiltration systems on a household scale made the following impacts:

Cultural. The people involved appreciated the opportunity it gave them to protect the environment in which they lived, noting the difference between good and bad use of water. This type of eco-sanitation technology is becoming more important in Latin America. Experiences in the country and other countries in the region show these technologies are accepted by people.

Institutional. The Nicaraguan Government aims to provide alternatives in accordance with the country's economic situation. Without having to wait to implement technologies from developed countries that would not be sustainable, home biofilters are an alternative form of eco-sanitation, accessible to people that have no sanitary sewer service.

Science. Nicaragua only had experience in large scale treatment plants, where wastewater is taken to a common treatment plant. The biofilter alternative means that the problem can be tackled at source, adapted to people's needs.

Economic and financial. The reuse of water treated with biofilters produces financial savings in general and savings for the families that operate the system. Since these waters do not flow into municipal sewage systems, they can reduce the amount of effluent in those systems, which typically have high and long-term operating and maintenance costs. Home Biofilters treat greywater at the source. Unlike conventional treatment systems, they do not require a sanitary sewer to channel water, so there are no maintenance costs.

Several institutions, municipalities and private companies have shown interest in using this technology to improve household sanitation. Currently capacity building courses are being provided for technicians to enable them to design and construct home biofilters.

As regards chemical and biological parameters, home biofilters are an appropriate technology for the treatment of domestic greywater, provided that the proper design criteria are used and maintenance is guaranteed by the people concerned.

Implementing home Biofilters in other countries

This technology is simple to implement and does not require skilled labour. The construction method follows the concept: self-built with technical assistance, so that the families who choose this alternative can themselves build the biofilter, with technical support. Based on experiences, the methodology when applied to other countries could include the following steps:

Involvement of competent institutions

The first step is to involve national institutions responsible for water and sanitation, and social organizations interested in participating in the implementation of biofilters. For example, in Nicaragua ISSUE-2's main partners carry out the following functions:

- Centro de Investigación y Estudios en Medio Ambiente CIEMA: with their experience in the construction of biofilters in the country, they provide statistical data for the design of home biofilters, in accordance with the environmental, biological and indigenous conditions of the region. CIEMA evaluates the effectiveness of biofilters, comparing influent and effluent water.
- Delegación V Alcaldía de Managua: promotes home biofilters among inhabitants as an alternative form of greywater treatment to improve the environmental conditions of neighbourhoods that do not have sewage services.
- HABITAR: identifies families interested in using this technology, funded through micro-credits. HABITAR is responsible for training the local workforce and families, also providing technical assistance before and during the construction of the systems.
- Asociación de Microfinacieras de Nicaragua ASOMIF: manages a guarantee fund to channel micro credit to the environmental services sector and facilitates access to funds for low-income families interested in implementing home biofilters.

Promotion and awareness campaign.

The main aim of the campaign is to show residents how they can raise their living standards through proper sanitation, and demonstrate the effectiveness of biofilter technology for the treatment and recovery of greywater, highlighting the benefits in both environmental and economic terms. At the same time, users are encouraged to provide proper maintenance to keep the system efficient

Location and site

A survey is carried out of the households that wish to acquire the technology and then an assessment is made of the area available for location. To define the site or area where the biofilter is installed it is important to:

- Analyse the locations of influent and effluent of greywater (bath, laundry, disposal site, etc).
- Verify that the site is level, taking into account that the land should not have a slope of more than 5 percent.

Financing

Economic sustainability for the acquisition of biofilters is promoted through social credit, which originates from donations. The maximum term is one year with an annual interest rate of 7%. Taking into account the economic situation of the people, repayments are agreed in consultation with users and are either fortnightly or monthly. Credit is given in the form of building materials, prior calculation and agreement with the participating families.

Home biofilter design

A study is made of the number of people per household, water usage, provision of drinking water, in order to estimate the equipment needed and possible daily discharge of water from the households. These data are necessary to design the biofilter to the right size.

Note that a standard model does not exist for this technology because each is designed with different conditions in mind; however, it is possible to set a standard when working in highly homogenous areas.

Technical assistance throughout the process

Workshops are organized for the families that are constructing a biofilter so that they are directly involved in the work. Technical assistance is given at different stages of homes biofilter implementation, starting with capacity building, then during construction and on completion of the system.

HABITAR has experience in transferring knowledge of the design and construction of this technology to technicians, who do not necessarily have to be specialists in the subject. As it is a simple system, theory and practice can be learnt workshops. So far in Nicaragua more than 90 technicians have been trained in different regions of the country and this has facilitated the promotion of the technology, which is now incorporated in the design of projects by trained technicians.

International interest

Home biofilter technology has already been adopted in several Latin American countries. The ISSUE-2 programme receives assistance from the Asociación Centroamericana para la Economía and the Costa Rican Salud y el Ambiente (ACEPESA), the agency responsible for the ISSUE programme in that country.

Spanish cooperation is currently providing support on issues related to water and sanitation. Through the Alliance for Water Programme and the Government of Aragon, which is responsible for financing such projects in Nicaragua, a donation has been granted for the implementation of 100 systems in 100 households in ISSUE-2 target areas.

Home Biofilters won first prize in the 2009 edition of the Innovation Competition for Human Development, organized by the Nicaraguan Council of Science and Technology (CONICYT), in collaboration with major international and national organizations operating in Nicaragua

Further Information

More information on home biofilter systems for greywater treatment can be found in the minutes of the following events:

- Feria Tecnológica de la UCA, 2008
- Intercambio GIRS AMUNIC-HABITAR, 2009
- Foro Nacional de Reciclaje, 2009
- Pasantía Perú sobre intercambios de experiencias, 2009.
- Capacitación sobre diseño y construcción de Biofiltros Domiciliares (AMUNIC - HABITAR), 2010.

The article:

- D. Mara y G. Sinnatamby, Método Racional Analítico para el diseño de tanques sépticos para climas cálidos y tropicales, The Public Health Engineer, No 14,4 (1986).

HABITAT's website:

www.habitarnicaragua.org

Contacts

The Centro de Estudios y Promoción para el Habitar can provide technical assistance on system design, management methodologies and start-up for those interested in adopting the home biofilter technology. For more information and to establish partnerships, please contact:

Héctor Delgado, ISSUE-2 Programme Coordinator

William Pérez, Technical Assistant

Centro de Estudios y Promoción para el Habitar
Estatua Montoya 3 ½ c. al Norte.
Phone: 22683136
E-mail: oficina@habitarnicaragua.org

The IDEASS Programme - Innovation for Development and South-South Cooperation - is part of the international cooperation Initiative ART. IDEASS grew out of the major world summits in the 1990s and the Millennium General Assembly and it gives priority to cooperation between protagonists in the South, with the support of the industrialised countries.

The aim of IDEASS is to strengthen the effectiveness of local development processes through the increased use of innovations for human development. By means of south-south cooperation projects, it acts as a catalyst for the spread of social, economic and technological innovations that favour economic and social development at the local level. The innovations promoted may be products, technologies, or social, economic or cultural practices. For more information about the IDEASS Programme, please consult the website: www.ideassonline.org.

IDEASS

Innovation for Development and South-South Cooperation

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In the interested countries, ART promotes and supports national co-operation framework programmes for Governance and Local Development - ART GOLD. These Programs create an organized institutional context that allows the various national and international actors to contribute to a country's human development in co-ordinated and complementary ways. Participants include donor countries, United Nations agencies, regional governments, city and local governments, associations, universities, private sector organizations and non-governmental organizations.

It is in the framework of ART GOLD Programmes where IDEASS innovations are promoted and where cooperation projects are implemented for their transfer, whenever required by local actors.