A guide for an Integrated system of ecological sanitation in suburban and rural areas

ECODESS

FONDO DE LAS AMERICAS PERU

WATER For PEOPLE

AVINA

CENCA Instituto de Desarrollo Urbano

29 Years

The Institute for Urban Development CENCA is pleased to present this document, with the objectives to contribute to forming a knowledge base of new work being done in relation the theme of Ecological Sanitation in Peru and thus facilitate the replication of these new experiences. This collective work contains a product that that is somewhat a new practice in our country.

Equally as with our previous publications: "Innovative and sustainable proposals for the disposal, treatment, and reuse of solid waste and domestic liquids" 2002, and "Ecological Sanitation: Lessons learned in the suburban areas of Lima" 2006; we intend to provide evidence for new forms of practicing sustainable sanitation that today, more than ever, plague the planet and those who live in rural or urban environments and require as a paradigm of mitigation and adaption to the effects of climate change.

CENCA, in this document, reaffirms its commitment for a dignified and possible world, the same that we sought when we formed ourselves 29 years ago and began the pioneering implementation of Ecological Sanitation in 1997.

A guide for an integrated system of ecological sanitation in suburban and rural areas

ECODESS

Lima, March 2009
First edition.

This document has been made possible thanks to the participation of the following professionals or institutions

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Prologue

The predominant economic system en the world has abused and abuses the goods that are provided to us by nature. Water resources are no exception and below the deeply rooted believe that its abundance is developed technologies that consume in irrational manners. Climate change puts us today on alter to the most consequential of these actions, that which requires us to make profound changes to our paradigms and not mere "improvising."

According to research, the natural ecosystems will be gravely affected by climate change and water cycles. From the Report on Human Development from the United Nations in 2007-2008, the accelerated deglaciation in the tropical snowcaps threatens the water sources of the city populations, along with that of agriculture and the production of hydroelectricity principally in the Andean region. During just a few decades, approximately 1.8 billion more people are suffering for lack of water. Altered rainfall with attendant droughts and floods is now directly impacting the livelihoods of rural and suburban communities and the future scenario of the cities will be marked by water stress.

The urban environment is closely linked to natural ecosystems in which it was built and with which it interacts. It depends on them to provide the resources to ensure its existence. In this regard, in Peru, a Law on Water Resources with environmental and social coherence is required to have a Comprehensive Management Plan Water from a holistic and sustainable approach that includes guidelines for proper management of watersheds and to incorporate the dimensions of: harvesting, planting, production, care, treatment and reuse, as was said by Dr Nicole Bernex.

In this sense, ecological sanitation initiatives for rural and suburban areas provide valuable information on alternatives for saving water and wastewater treatment at the neighborhood level, and become important in the context of conservation policy and conservation of water resources that has been promoting the housing sector. The "A guide for an Integrated Ecological Sanitation in suburban and rural areas", prepared by a team led by Architect Juan Carlos Calizaya, pioneered the application of ecological sanitation in Peru and propellant system ECODESS in our country develops progress of this initiative and believe that will be useful for the social, economic, authorities and population to obtain an input guiding investments in water and sanitation.

Dr. Roció Valdeavellano R.
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Coordinator

Introduction

Same as other countries in Latin America, Peru is observing an intense process of urbanization, centralized in the big cities. Now, more than ever, to appreciate the accentuated social difference and the consequent exclusion of the most poor, who inhabit the suburban areas, have difficulty feasibly accessing, among other aspects, of conventional services. Thus, on the national level, these, among other, the following problems:

a) Lack of water and sanitation services

In the year 2008, the population of Peru was 28.5 million inhabitants; of which 6.5 live in rural areas. Of this population, 3 million do not have access to potable and 5.5 million lack adequate disposals for sewage and wastewater. In the urban environment, 3.7 lack potable water and 6.2 million lack sanitation. Of them 0.9 are concentrated in Metropolitan Lima, most in the suburban areas[1].

In summary, for every five people, one does not drink safe water and one of ever two does not have a complete bathroom in their house.

b) Environmental degradation for the protection of wastewater in the river, sea, lakes and soil

In the national environment, less than 22% of the wastewater is treated; of that only 15% in the provinces. What is left is thrown into the river, sea or the ground. Of almost 18,000 liters of collected wastewater in Lima, approximately a third is a product of the use of potable water to transport human waste.

c) Water Crisis and the lack of clean water in the coast of Peru

In Peru, there exists a process of thawing in the Andes Mountain Range. This situation began 150 years ago and it is estimated that by the year 2025 there will only exist 1,000 m^3/person/year of usable water[2], a situation that places the country in a "water crisis. [3]"

d) Limited investment in the infrastructure to cover the deficit of water, sanitation and treatment of wastewater.

It is estimated that the required investment in Peru to cover the deficit of water and sanitation is $4,200 million and of them no less than $2,500 million is that what is required for sanitation. 60% of the rural population is found in a condition of poverty and 24% in extreme poverty, living on less than $234 US per person per year.

e) Sanitation technology that adequate housing does not consolidate or guarantee the human right to good health.

Between the diverse factors that influence the difficulty to incorporate sanitation, we find that: the locations of the latrine usually are not less than 5 meters from the house, a situation that does not promote the habit of washing the hands of children and adults. Moreover the conventional system of hydraulic drag does not adapt the flooded soil and to the scattered settlements. This absence of services of sanitation for the poorest of the country is a cause of infant mortality.

f) Lack of green areas in the urban zone of the Peruvian coastal region

The big cities in Peru are located in the coast. 30% of the urban population is found in these uncultivated areas with a lack of water.

Making potable water, sanitation, and water treatment services more available are promised by the state before the Millennium Goals, but given the diverse geography of the country, it is difficult to identify the appropriate mode which these services can be viable and sustainable, especially considering adequate housing needs for the 12.5 million inhabitants who now do not have bathrooms in their homes.

Before these problems and the given limitations of management of the conventional services, in the last few years diverse institutions in Peru are developing new focuses and new models of technology to to find the situation and seek to change the technological paradigms

[1] National Plan of Sanitation 2006-2015

[2] Available freshwater is easily accessible to be drinkable, be it underground, from lakes, or rivers

[3] Eng. José Rivas, General Director of the National Institute of Natural Resources of Water and Soils, year 2002, Eco-dialogue 2002

of management, of which they can guarantee the social and environmental sustainability of the service.

The Institute of Urban Development CENCA, that is one of the institutions that since 1997 has developed interventions with the base focus of Ecological Sanitation[4], has achieved the design of a model of management of sanitation, called the ECODESS[5] – Ecology and Development with Sustainable Sanitation.

The present document describes ECODESS and its social, economic, technological and management components, putting emphasis on the methodological aspects, the constructive and the development of the abilities of others. It contains relevant information about the advantages and useful impacts for the implementation in the peri-urban and rural areas of the country. The objective is to provide criteria for intervention for all of the institutions that desire to implement ECODESS or utilize some of its components. It has a reference source that is the appropriation process of the development model in human settlements of 80 families in the zone of Nievería, district de Lurigancho, Chosica[6], in Lima, the capital of Peru.

The chapter that refers to lesions learned and recommendations identifies the divers possibilities of the application of ECODESS that were utilized in other experiences, as alternatives for the development of research and pilot projects. After four years of working on this project, CENCA, with the help of the Fund of the Americas (FONDAM) and the Program of Water and Sanitation (PAS-BM), sought to learn from the experience of user and from a collective manner, through the Interinstitutional Consulting Committee (CCI-ECODESS)[7], find and generate guidelines in which to seat the base of management, both integral and multidisciplinary of water and sanitation alternatives.

The interest to promote national legislation that encourages recyclability and investment in ecological sanitation is based in sustainable criteria. Also facilitates the design of new policies of investment in water and sanitation alternatives from diverse stances within the state (central, regional and local governments).

Before the need for sustainable alternatives to sanitation that are appropriate to the characteristics of the peri-urban and rural zones of the country, the ECODESS is presented as an option that enhances the capabilities of small operators, such as the JASS, contributing to achieve the completion of the corresponding Millennium Goals.

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4 to see the concept of ecological sanitation – ECOSAN in the document produced by CENCA, WSP, PNUD. "Ecological Sanitation: Lessons learned in the peri-urban areas of Lima." Lima, Peru, 2006.

5 Integrated Microsystems in the management of water and ecological sanitation, designed by Arc. Juan Carlos Calizaya, social entrepreneur ASHOKA, AVINA Leader, executive of the Institute of Urban Development CENCA, Coordinator of the program AGUAECOSANPERU/CENCA and member of the Network for Culture of Water in Peru.

6 Project of the donation of Dry Ecological Bathrooms, completed by CENCA with the management in financial help by the NGO CESAL and donations from the Community of Madrid.

7 The Interinstitutional Consulting Committee of the ECODESS (CCI-ECODESS), has as participants, representatives from the Office of the Environment of MVCS, the National Direction of Sanitation of MVCS, Fund of the Americas, PAS-BM, CENCA, National Agrarian University of La Molina, General Direction of Sanitation DIGESA, OPS, and SEDAPAL.

1. ECODESS as an alternative system of sanitation managment

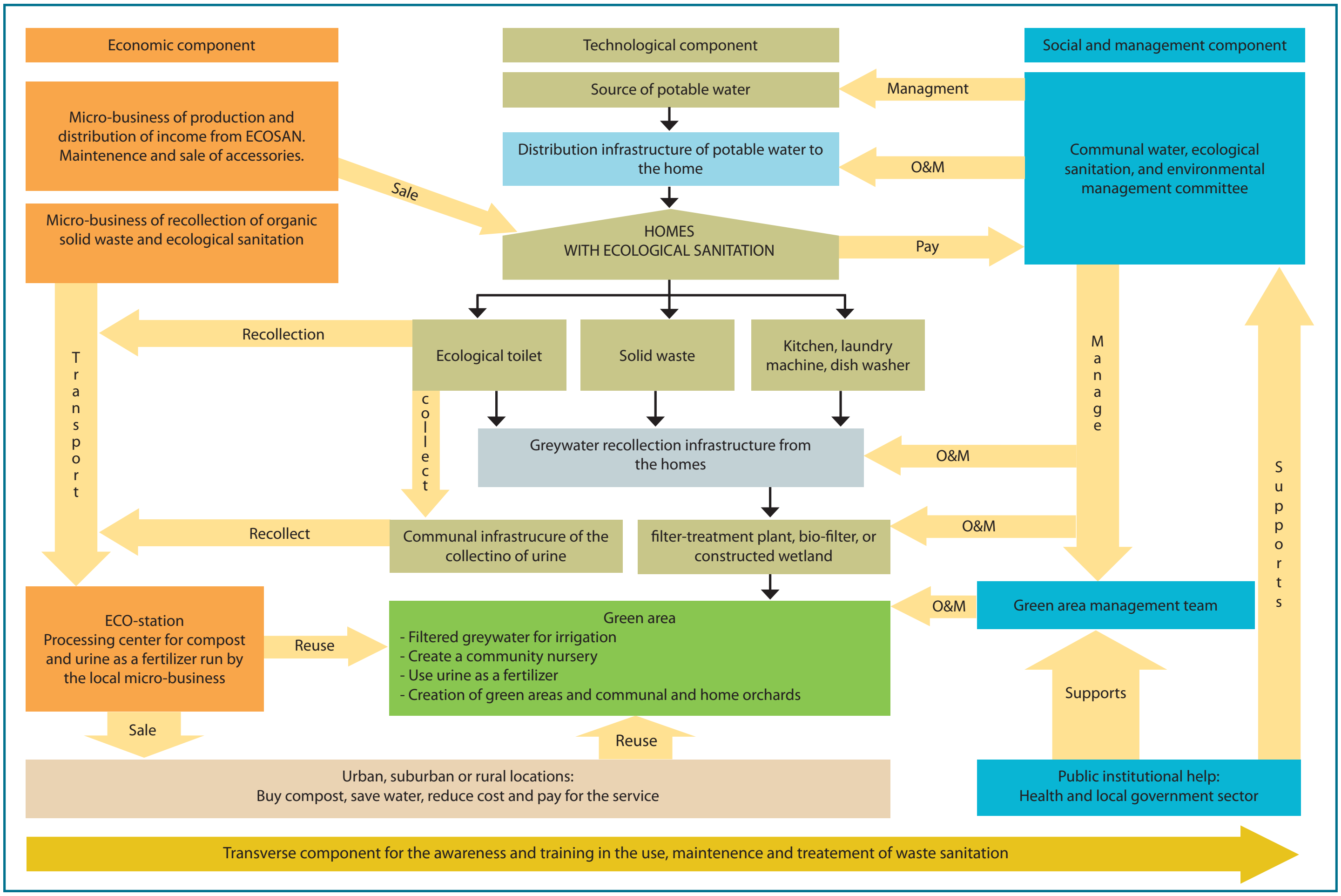
ECODESS is a comprehensive alternative for sanitation management, for permanent new urban, suburban, and rural areas of Peru. It contributes to a change in attitude in relation to a new culture of using potable water and sanitation. It promotes the separation, treatment and reuse of domestic waste (greywater and excreta) in different areas of intervention, such as: the home, neighborhood or town center. It promotes the participation of local actors in the decentralized areas, low modalities, community business, policy, or a mix thereof.

1.1 Description of the components of ECODESS and applied technology

a) Technological component wtih an ECOSAN focus, composed of two subsystems:
- Household subsystem.
- Nieghborhood subsystem.

b) Social and managment compontent.
c) Productive and economic component.
d) Transverse component of awareness and training.

Integrated system of ecological sanitation management – ECODESS

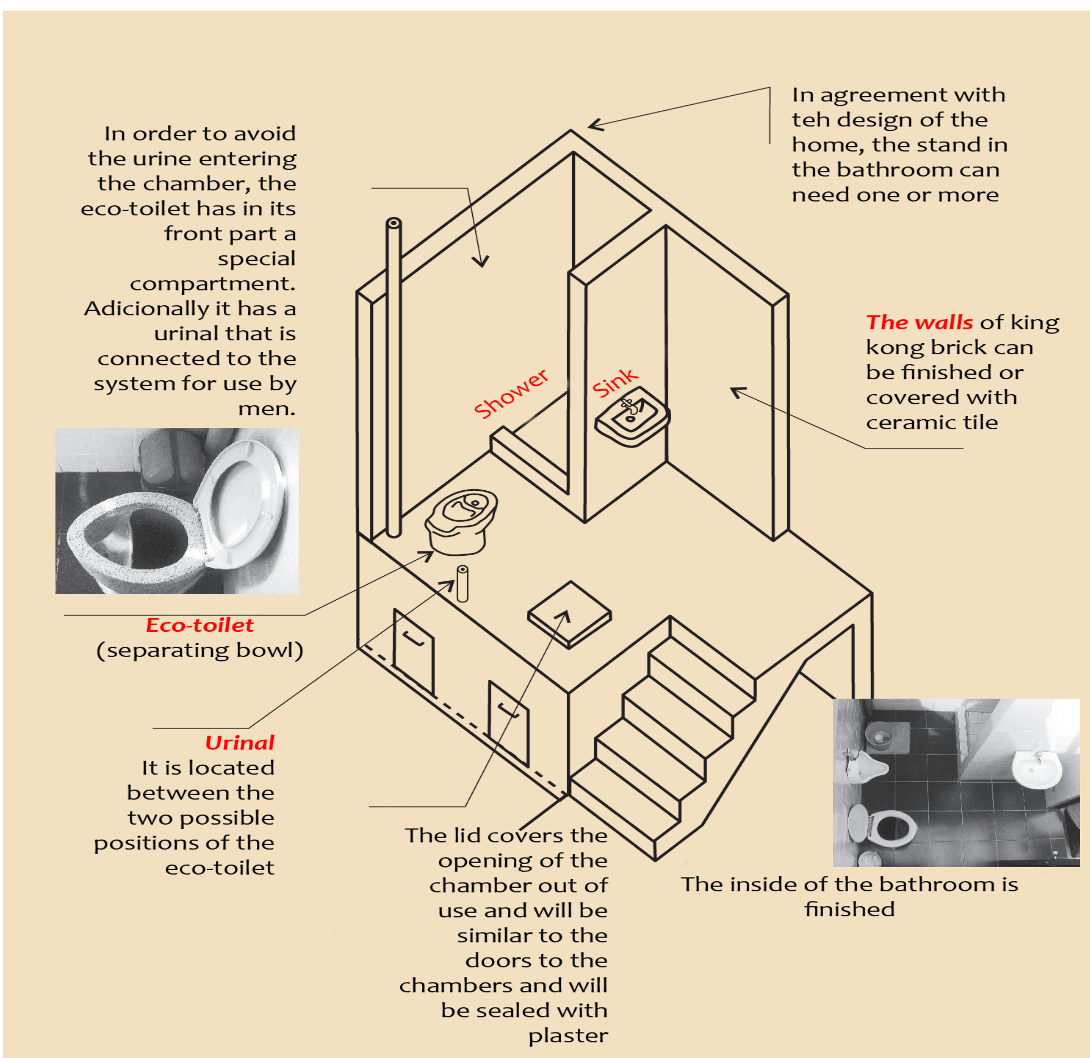


2. Technological compontent with ECOSAN focus

2.1 Housing Subsystme

It is located within the house, and includes: a complete bathroom (eco-toilet, urinal, sink, and shower), washing machine and network to collect the greywater that leads to a "grease-trap chamber" that also has a constructed wetland which treats the greywater, which produces irrigation quality water. The eco-toilet is toilet with a divider for urine installed in it. Below the eco-toilet there are placed chambers or containers in which the excreta is stored with dry material. When the chamber fills, the excreta can be removed and carried to a centralized eco-station in order to convert it to compost or dry material.

Fig. 2 Description of Urine Diverting Dry Toilet (UDDT)



2.1.1 Urine Diverting Dry Toilet (UDDT) as a basic unit of ECOSAN management

The Urine Diverting Dry Toilet (UDDT) is a hygienic module that is installed in the house, with ecological sanitation technology in its accessories, separates the waste and uses no water for the evacuation.

Fig. 3 Cross section of a UDDT

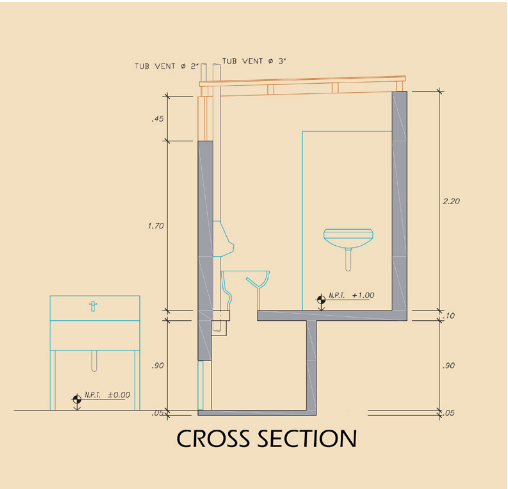
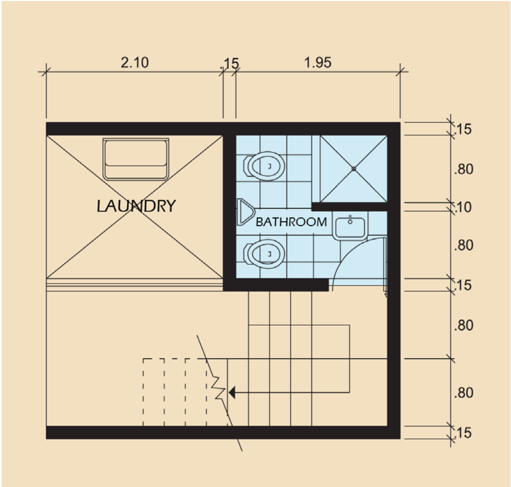


Fig. 4 Floor plan of a UDDT



a) Basic accessories for the instalation of an UDDT

- Eco-toilet.- Is a toilet espicially designed for ECODESS to separate the excreta from the urine. It exists in various models, such as:

Photo 1: Eco-toilet, shell type

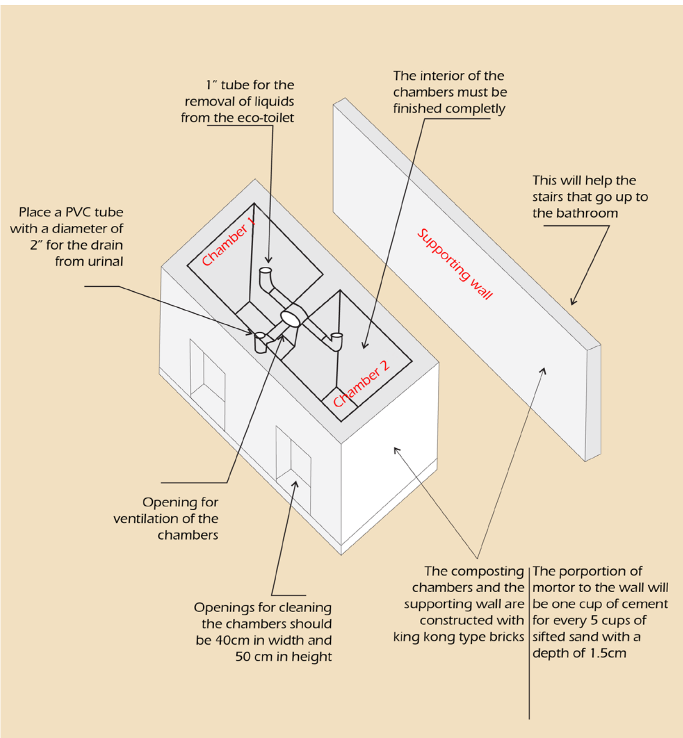
Material:
Granite base with cover made of fibreglass
Unit cost:
$48.00 US.

Photo 2: Eco-toilet for recessing directly above the storage container

Material:
iberglass
Unit cost:
US $30.00 + IGV
Does not include shell

- Drying chamber: They are cubicles for the storage of excreta and used dry material. Their volume is approximately 400 liters, that which permits an average storage of one year. It is also possible to use a container which should be removed continually in order to facilitate recollection.

Fig. 5: Chambers



- Urinal: is an accessory that is incorporated in the UDDT to contribute in reducing the consumption of potable water (no less than 5 liters saved) in the evacuation, in maintenance and hygiene.

Photo 3:

Material:
Fiberglass
Unit cost:
$20.00 US.

- Container: a mobile receptacle, that is used by the UDDT with only one chamber, and is used to receive the excreta, lime, and dirt. It is recommended to use impermeable material in order not to permit the entrance of liquids.

Photo 4:

b) How is a UDDT designed?

The design of the UDDT takes into account a series of basic critreia that can be qualified in the following manner:

- Criteria for easy use

The UDDT should permit a fast and easy evacuation of the waste from the storage chamber to the service zone in the house. It is important that such wastes can be evacuated without crossing the internal environments of the house. Therefore the use of an evacuation duct for the container that should be placed on the first level of the home should be centralized for all the waste.

- Criteria for location

It is important to have a service zone toward the sunny side of the house, with the objective to receive the solar heat in the chamber. This permits the heating of excreta and speeds up the drying process.

- Criteria of adaptation to terrain and the level of the building

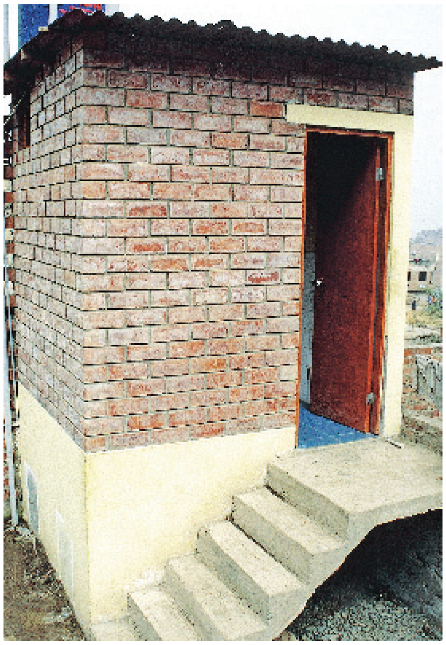
If the land is sloping, the design can take advantage of the difference in the height between the entrance to the UDDT and the removal of the waste. Wherever possible, this should be a difference of 0.80cm.

An alternative is to use the rest of the incline as an entrance to the UDDT.

- Criteria for participation of the user

The selection of a UDDT model has to be subject to direct participation from the population. In the case of the experience in Nievería, a process was developed holistic housing design and location for the UDDT. The selection of the type of eco-toilet is also an option and should be decided upon by the users.

Photo 5: Use of decending stairs at the entrance of a UDDT



c) How is a UDDT used?

- Use of eco-toilet

- For the correct use of a eco-toilet, the entrance of liquids into the storage chambers should be avoided because the decomposition of excreta is produced in an aerobic environment.
- The process of decomposition of the excreta is accelerated with the addition, after every use of the eco-toilet, of a small amount of the drying mix.
- The drying mix that should be used in the eco-toilets is one part fine, sifted, dry dirt mixed with live lime (CaO) or ash.
- It is recommended that the proportion be ¾ fine dirt to ¼ lime for the mix, but this proportion can vary depending on the user.
- After its preparation, the drying mix must be packed in bags and stored in dry environments until the moment of its use.
- For the use in the eco-toilet, it should be located inside the bathroom in a container that holds the drying material.

  Example: fill a receptacle with lime and mix it with sifted dirt in four receptacles of the same size. The mix can then be placed in the bathroom.
- After every use of the eco-toilet, the drying mix must be added with a sufficent ammount to cover the deposit. An amount equivalent to one cup (200g) of drying mix for use has been demonstrated to be sufficient in the eco-toilets installed in Nievería.
- Every thirty days, use a rod or stick, the excrements in the chamber should be removed and leveled. After removal, the exposed area should be covered with drying material.
- Toilet paper nor other organic waste should be put into the drying chamber in use or others.
- The eco-toilet should always be closed when not in use to limit the wafting of disagreeable smells and the proliferation of insects in the waste.

d) Mode of use of an UDDT.

The eco-toilet is installed and is placed above the two contiguous composting chambers, (from 300 to 500 liters of capacity for each one) of alternating use. Therefore when the first chamber is filled, the eco-toilet should be moved in order to use the second. Once the second chamber has been filled, the contents of the first will have dried and turned into a waste that looks innocuous, dry, and odorless. A time of maturation no less than six months is recommended for each chamber.

- Cleaning an eco-toilet
- Prepare a solution of bleach (sodium hypochlorite) dissolved in water with a proportion of 1/6 water that should be applied one time per week.
- Make a swab with a stick wrapped in cloth or sponge.
- Moisten the swab (without soaking) in the bleach solution and rub on the inside of the eco-toilet.
- Dry the clean surface with a clean, dry cloth. It is important to avoid getting the solution in the storage chamber.

- Cleaning the urinal
- The same as in the case of the eco-toilet, a swab with a cloth should be prepared, wet the solution with bleach and swab the surface of the urinal.
- After the urinal should be rinsed with water.
- Repeat this operation one time per week in order to evade the formation of deposits on its interior.

- Drying material

The drying material is a mix of dirt with lime (CaO) or ash, with a relation of 3 to 1 in the first case or 3 to 2 in the case of ash. Its function is to absorb the moisture of the excreta, which, under normal conditions, has 75% humidity. The lime dehydrates the stool, raising the temperature and therefore destroying the pathogens. Most of the time, this contact of the excreta with this compound is most effective in the destruction of the pathogens.

Properly functioning Urine Diverting Dry Toilets require the deposition of solid waste in chambers sealed off from the flow of air in order to permit the aerobic decomposition of organic material and the proliferation of aerobic bacteria (nitrifies, heterotrophic, etc.) and to reduce the presence of pathogenic aerobic bacteria. To accelerate the process of decomposition and stimulate the increment of aerobic bacteria, a mix of inorganic material should be applied on the excreta ever time that the eco-toilet is used. The drying mix should include farm sifted dirt and lime (CaO). The recommended proportion of excreta and of drying mix inside the eco-toilet should be 1 to 1. It should be mentioned that human excrement can contain approximately 80% water, of which is evaporated during the maturing process, whose result can be presented in high contents of inert and low organic contents in the final waste.

The aerobic bacteria permit the oxidation of organic carbon and the excreta in the presence of oxygen according to this reaction:

$$C_{(org)} + O_2 \rightarrow CO_2 \quad (1)$$

The CO2 released by oxidation is released into the environment, but part of it can be captured by chemical reactions with the lime (CaO), which also has the function of providing and alkaline environment in the mix, encouraging bacterial growth.

$$CO_2 + CaO \rightarrow CaCO_3 \quad (2)$$

The recommended use in homes in suburban and rural areas, because they have more space and a single base unit can meet the needs of a family. This eco-toilet can be the shell or recessed type and can be built gradually. The material of the stand can be wood or adobe. It is mostly used in one story homes.

2.1.2 Topology of UDDTs applied in Lima

- Two chamber UDDT

Its use is recommended for homes in suburban or rural areas, because there is more space available and one unit can meet the needs of a family. This eco-toilet can be either a shell type or recessed and can be made step by step. It can be made of wood or adobe. It is mostly used in homes with only one story.

Photo 6: Two chamber UDDT

Foto 7: UDDT with wood base

Foto 8: Two chamber UDDT with recessed eco-toilet

- One chamber UDDT

This eco-toilet, either shell or recessed types, holds inside one chamber where is placed a container whose size depends on the volume of the chamber, is idea for houses located in suburban areas that do not have extra space. It is also recommended for use on higher floors of a house. It is important that the emptying of the containers is done in the yard or the servicing zone of the house.

Photo 9: One chamber, recessed, UDDT

2.1.3 Collection network and treatment of greywater in the home

- Characteristics of greywater

Greywater is comes from the water used in the shower, washing machine, kitchen, and dishwasher, not including the toilets. Compared with black water, in greywater there is found fewer pathogens because they lack direct contact with fecal matter. But they are not except from them, there exists a risk from the use in the cleaning of clothes, diapers, and showers. A few authors[8] signal that the growth of enteric bacteria, such as fecal coliforms, is favored in greywater thanks to the presence of easily degradable organic material. Calindo et al (2007) found that a concentration between 9.2 x 10^2 and 2.6 x 10^5 NMP/10ml de fecal coliforms are found in the greywater from one human settlement in the city of Lima.

The use of separating systems of feces, urine, and wastewater as a strategy of ECOSAN, avoid incorporating the 50 liters of stool which prove the most dangerous elements of wastewater. The urine is relatively harmless and the greywater can be treated with alternative systems that require low are no use of energy, that are easy to operate and maintain and have a efficient operation to remove the pollutants from the water for treatment. The different technologies of treatment can include aerobic and anaerobic process; one of the options used often under the scheme of ECOSAN is that of constructed wetlands. This meets the above requirements and has the aesthetic value of plants, which allows it to be incorporated in public areas.

- Composition of greywater

Greywater mostly consists of salts (phosphates in detergents) and organic substances. BOD_5 values in the same human settlement in Lima that oscialte between 180 and 345 mg/l, while Pansonato et. al. (2007) reports values between 90 and 360 mg/l for a house in Campo Grande, Brasil. On the other hand the greywater presented a lower amount of nutrients compared to the values found in feces and urine (see box n. 1)

Table n. 1: nutrient loads from the three main components of domestic wastewater

Product	Volume produced (l/ person. year)	Características microbiológicas	Nutrients		
			N (%)	P (%)	K (%)
Urine	300-500	Low content of pathogens Higher content of hormones and drug residues.	87	50	54
Feces	30-50	High content of pathogens.	10	40	12
Black water	7,500 – 30,000	High content of pathogens.	5	15	10
Greywater	15,000 - 30,000	Low content of pathogents which come from clothes, shower, and diapers contaminated with fecal matter.	3	10	34
		TOTAL: kg /person. year	4-5	0,75	1,8

Ref: Elaborated from Gulyas H. (2007) and Winblad et al (!998)

[8] Gulyas Holger (2007). Greywater reuse: concepts, benefits, risk and treatment technologies. En International Conference on Sustainable Sanitation. Fortaleza. Brasil.
- Platzer Christoph. (2007). ECOSAN in Brasil and Perú. Experiences and points of view from a company. Exposition at the International Conference on Sustainable Sanitation. Fortaleza. Brasil.
- Sergio Rolim Mendonca. (2000). Stabilization of Pond Systems. Mc Graw Hill. Colombia.

a) Recollection, treatment, and reuse of greywater in Nievería

The intervention made in 43 homes in the Housing Association, Los Topacios and includes two technical subsystems. Now there are fifteen additional homes that have been connected to the greywater collection network. The domiciliary subsystem of greywater recollection captures the urine from the eco-toilet and from the urinal for the men and mixes that with the greywater that is received from the bathroom (sink and shower), washing machine, and kitchen sink.

- Internal network

The liquids are recollected within an internal greywater network can gather approximately 50 liters per day per household. Finally the greywater goes through a treatment process by traveling through a grease trap and then through a constructed wetland or bio-filter..

For the collection network on the household level, a PVC pipe with a 2" diameter is used. This tube is designed to recollect water from the bathroom sink, shower, urinal, flow of urine from the eco-toilet and from the other sinks. For the correct operation, the other necessary accessories (elbows, valves, etc.) and a concrete box of 0.40cm x 0.20cm are installed.

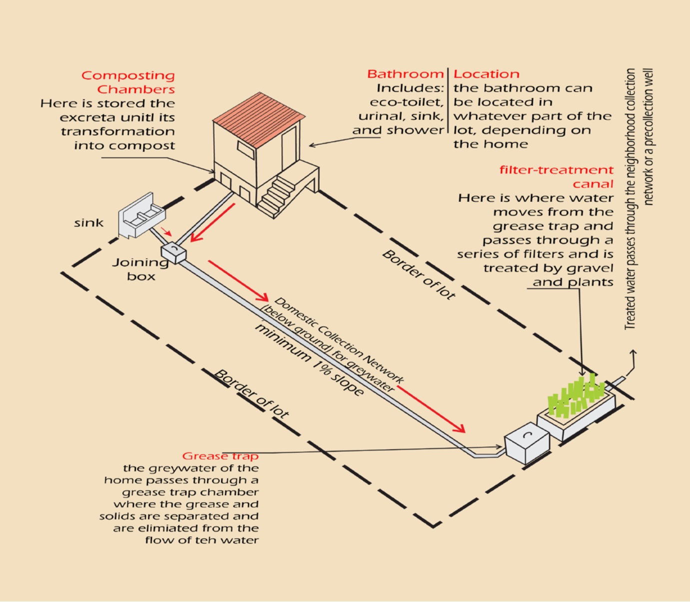
- Greywater treatment process

The treatment process is shaped for two units, the grease trap and the constructed wetland/bio-filter.

The first unit of the system is the grease trap chamber, which has a length of 50cm, 25cm wide, and 60cm deep. This chamber in total has a volume of 50 liters.

The grease trap Is located within the lot, along the path of the greywater and urine. Inside it retains the grease particles and other solid elements that are found in greywater. Because of its low density, the crease rises to the surface of the water, which permits its separation, and can easily be removed.

Fig. 6: Subsistemas domiciliarios



The water that leaves the grease trapping chamber is carried through a PVC tube with 2" diameter to the bio-filter or horizontal subsurface flow wetland (constructed wetland). The constructed wetland is a system that consists of three principal components: plants, microorganisms and a mean of support whose interaction gives the result of removing contaminates for means of physical, chemical and biological mechanisms. The subsurface flow permits the installation of this treatment unit in public areas because there is no risk of contact with the water.

Bio-filter.- Is a constructed wetland with subsurface flow. In the homes of Nievería, beds of concrete with the dimensions of 1.90m length by 0.48m wide and 0.60m deep were used. The base for these dimensions were considered for five inhabitants per home and it was estimated that it would utilize an area of 0.18m^2/inhabitant, but it is recommended to have a space of 1m^2/inhabitant.

The box should be made with substratum that are 0.40m thick and is filled with crushed rocks of 3/8" in diameter (se figure

Photo 9: Grease trap design

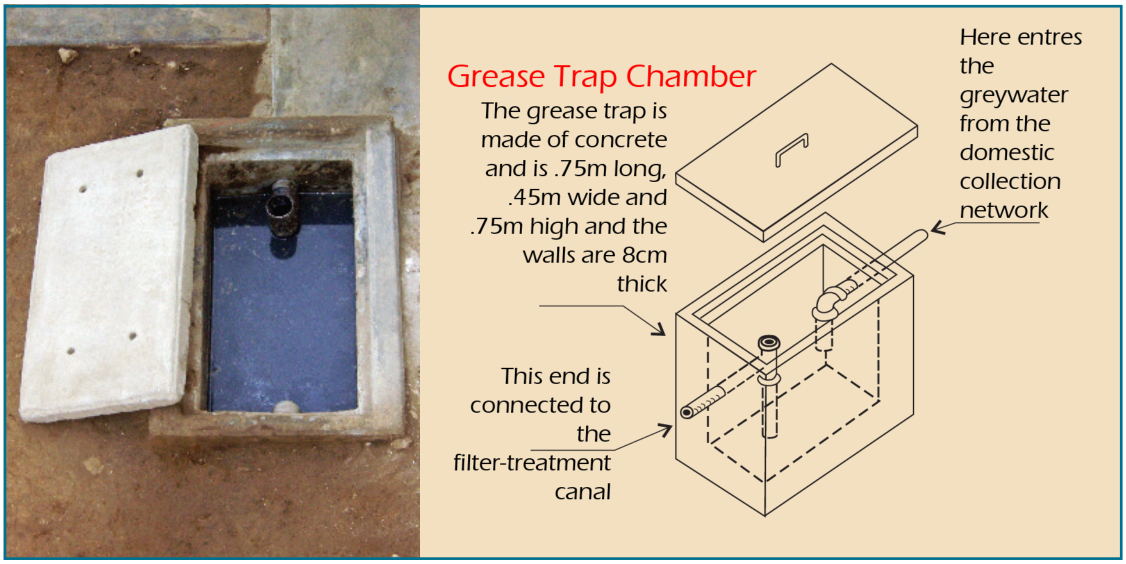
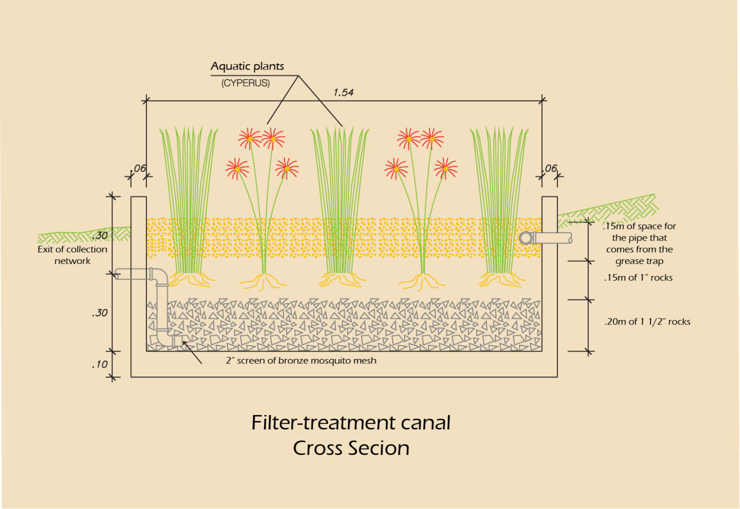


Photo 10: Grease trap chamber and household constructed wetland system. Housing Association, Los Topacios, Nievería, Lima

Fig 7: Design of household bio-filter



n.5). The function of the substratum is to support the plants and microorganisms that decompose the organic material and are also directly responsible for the elimination of some contaminated substances that come from the physical and chemical interactions.

The plants utilized belong to the species Cyperus alternifolius (see fig. n. 6) and perform different functions: the superficial area of the roots are essential for the colonization of the microorganisms that intervene in the decomposition of the present contaminates in the untreated water, the stems provide shade to reduce the growth of surface algae in the wetland and conditions the temperature which is as important in cold climate as with the warm ones.

Photo 11: Cyperus alternifolius, the plant used in the constructed wetlands in Nievería

b) Operation and maintenence of a greywater treatment system

In the bathroom and kitchen sinks:

- Avoid putting food waste or other objects that can jam the collection tubes into the system.

In the grease trap:

- Avoid adding other water to the grease trap because that can impede the natural separation of the grease.
- Clean the accumulated grease and solids once or twice a week; this will depend on the level of accumulation of the waste. For this it is necessary to use a manual collector for the grease and a spatula with a long handle for the solids.
- Once they have been removed, put the deposits together and cover them with dry material (sand, lime, ash) until their elimination, along with household garbage.

In the constructed wetland:

- Check to make sure that there is not a flow of water over the surface of the wetland. If this is the case, check to see if there exit pipe is obstructed or if there is excess accumulation in the lower levels of the bed.
- If solids have blocked the tubes, remove the rocks from the bed, clean them and return them to their place.
- Maintain a regular coverage of plants throughout the entirety of the bed.
- Control the height of the planted plants, trimming or pruning will be needed from time to time.
- Verify once or twice every fortnight to make sure that the entrance is open to prevent chocking the system.

As of now every user is responsible for the cleaning and maintenance of their system, however it should be noted that this work will be taken over by the business, Aguas de Nievería.

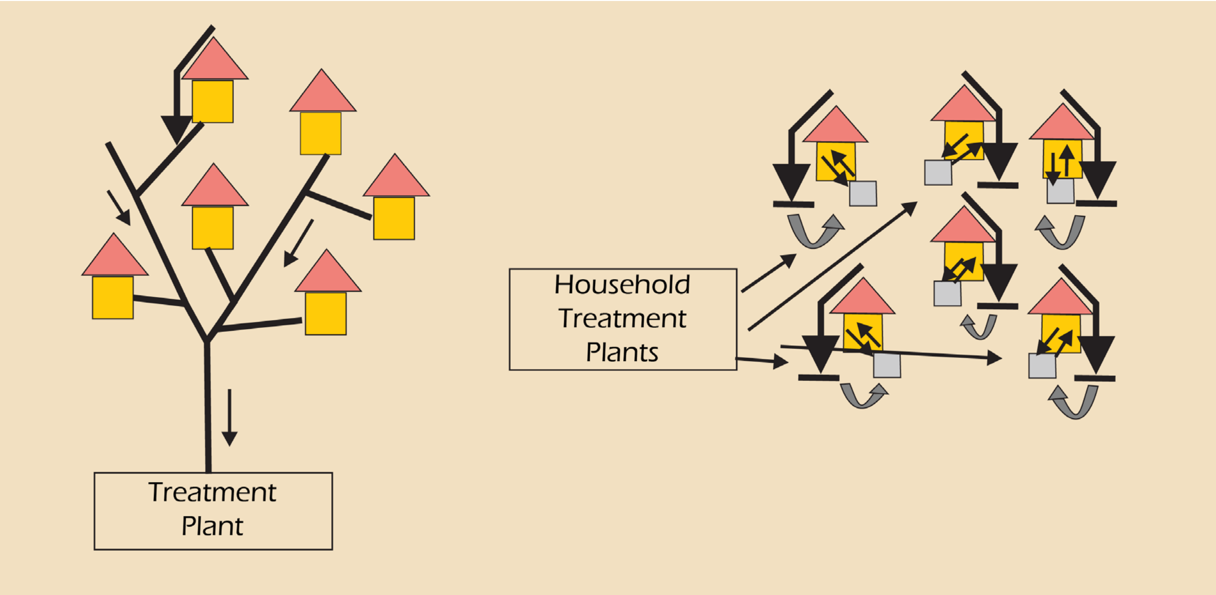
Oswald and Hoffman (2007) report that in the experience of Nievería, three years after its implementation, 20% of the systems were covered with plants in more than half of their surface, 38% did not have plants, only the gravel bed, and 18% of the systems were out of use.

2.2 Neighborhood subsystem

The greywater treatment systems can be made in centralized or decentralized ways, depending on the availability of land in the home with or without the intended use of treated water. One decentralized system applies when the treatment of the greywater happens within the home and for this the construction of a constructed wetland should be considered. In the case of the Housing Association, Los Topacios of Nieverí, it was opted for this system due to the face that there was not an available area for a centralized constructed wetland. This model can be applied where the homes are very disperse. A centralized greywater treatment system is one that captures the greywater of the homes within a collection network and then carries them to the central constructed wetland where it can proceed to treat the entire flow of the recollected greywater.

A neighborhood system consists of a sewage system that collects the communal waste into a greywater treatement system that is designed for one system for every 43 connected homes; therefore the design is projected for the recollection of greywater from a total of 90 lots of the Housing Settlement Nievería. The final discharge flows into an irrigation canal.

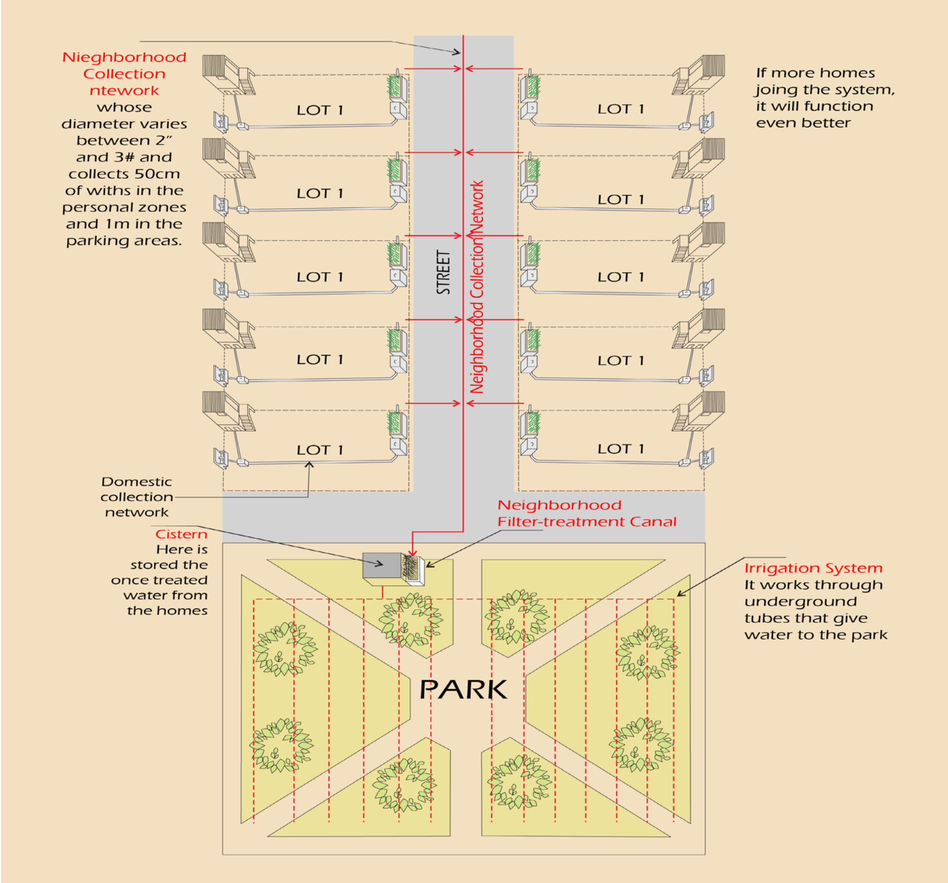
Fig. 8: Options for development of ECOSAN treatment systems



2.2.1 Comunal external network for the recollection of greywater

A second external collection network collects the treated greywater from all of the connected lots and leads them to the cistern, from which it goes to an underground irrigation system for the maintenance of the green areas. In this way, instead of having many individual bio-filters, one centralized filter can suffice.

Fig. 9 Distribution plan for a communal collection network



ECODESS tries to keep greywater for the reutilization in irrigation, contributing with that to the optimization of water resources.

The design of the greywater collection network takes into consideration specifications and calculations of flow established for the standards of design and approved communal sewage by the Ministry of Housing, Construction and Sanitation[9].

a) Evaluation of the quality of water from a greywater treatment system.

In 2004, one year after the instillation of the treatment system in Nievería, *Lopez (2004) completed fieldwork to evaluate the quality of the system. Spot samples were taken of the water in the grease trap and three samples at the output of the system, two at each point of discharge of the water to the irrigation canal. Afterward, in 2006, a new evaluation, by **Aspira and Ivares, was evaluated at a point of discharge of the water into the canal. The average values of the monitored parameters are shown in Table n. 8.

9 National building regulations, published in El Peruano on June 8, 2006.

Table n. 2: Average values of greywater monitoring at the Nievería Treatment System

Point of sample	N total mg/l	P total mg/l	DBO_5 mg/l	Total solidsmg/l	Suspended solids mg/l	E. Coli NMP/100 ml
Grease trap*	195,4	0,7	125	830	75	-
Discharge of canal*						
- Punto 1	146,6	0,15	250	850	70	$4{,}6x10^5$
- Punto 2	30,4	0,12	60	750	26	$2x10^4$
- Punto 3	11,2	0,68	40	730	27	90
Discharge of canal**	-	11,6	79	-	-	$1{,}6x10^5$

* López, 2004
** Aspira and Ivarez, 2006
Source: CENCA, WSP, PNUD. 2006

Aside from the results demonstrated in Table n. 2, it is observed in general terms that this system is removing approximately 50% of the organic load. The exception is the communial network which descharges into the canal at discharge point number 1, which seemed to be suffering from cross contamination, probably because of untreated sewage entering the system. With relation to the microbiological quality in the effluent, it was observed that the quality was not homogenous, again showing greater contamination at discharge point number 1. Only discharge point number 3 would comply with the established Class III General Law of Water which is currently using the water in the canal from the discharge effluent.

b) Costs of construction of a gerywater recollection and treatment system in Nievería.

The direct costs of construction of an internal collection network of the communal network and of the greywater treatment system have been estimated for every home in the following manner: costs of the internal collection network: US $30=; costs of greywater treatment system: US $100=; costs of neighborhood system: US $23=.

Suggestions

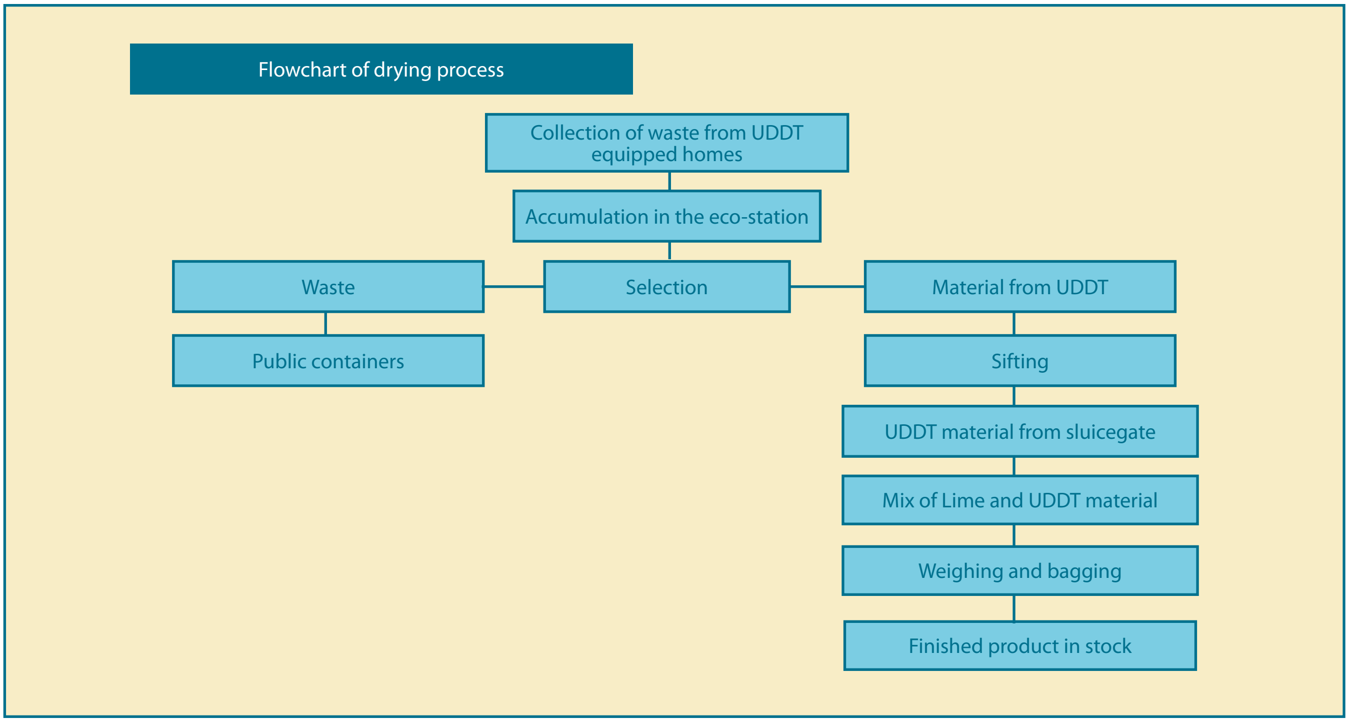
- The applied means in the bio-filter respond to the ground space limitations in the location. It is recommended to have a surface of no less than 1m2 per inhabitant to have the most effective removal of contaminants.
- It is recommended that the grease trap is located in the service area´s central patio, right behind the discharge of the kitchen sink. This will keep grease buildup in the tubes that lead through the bio-filter system.
- To make they process more efficient, it the installation of a small septic tank or Imhoff pit before the bio-filter is recommended in order to prevent the rapid filling of the bio-filter´s bed.

2.2.2 Eco-station

After cleaning, collecting, and sampling, the waste needs to be taken to one of the most important components of ECODESS management, the eco-station. There the treatment and reutilization of the waste from the UDDT and other activities can be done, there one will find:

- Collected waste storange
- Treatment of waste (dried with or without reuse)
- Preparation of dry material
- Dry material container

Fig. 10: Flowchart of treatment



- Administration.
- Storage of tools for cleaning the chambers, waste collection, treament, and the packageing process.
- Storage of processesed material

a) Criteria for the design of the eco-station:

The eco-station should be located in a free area of the home with, at least, a radius of no less than 50 meters, in order to prevent the annoyances that come from dust or some of the smells that can be generated during the process.

If the drying material is formed with a mix of lime with soil, it is not able to be used to compost, but if the drying material would be organic (sawdust, ash, etc.), it can be used in the composting process along with other organic materials in small percentages. The aforementioned part is one of the key aspects of the design of the eco-station, it must be done with the type of drying material that will be used.

b) Treatment of the dry excreta in the eco-station:

- The obtained solid wasted in the chambers should be arranged in stacks of 50cm high.
- The waste will be ground and sifted through a mesh of 2mm in order to obtain a fine grain.
- This fine grain can be utilized in the preparation of a new drying mix and then reused in lieu of the mixture of fine soil and lime.
- Other uses of the fine grain is in the preparation of soils to be used in garden and for pots. The waste can be utilized in a mix with dirt from crop producing fields, washed sand, and/or decomposed organic materials.
- The solid waste can also be used in a mix with dry soil, in the tillage of adobe and bricks that are used for construction.

b) Methods of bio-security in the process of recollection and treatment

Personal methods

- It is recommended that the contact person be vaccinated for tetanus, typhoid, and hepatitis.
- It is recommended to have a medical checkup with at least an exam of tuberculosis and hemoglobin in order to verify that the worker is of good health.
- Personnel that takes the samples and analysis at the laboratory previously should have passed a medical check and be up to date on vaccinations.
- Personnel should be found to be in a perfect state of health. S/he should not have the flu nor problems or minor injuries to the hand or arm.

Methods and equipment for protection

- Do not start work without personal protective equipment, such as overalls, coveralls, gloves, a resperator, mask or rubber boots. Gloves should be reinforced in the palm and fingers in order to prevent cuts and punctures and should be worn outside the sleeves of the coveralls.
- Pull all hair back as to not contaminate it. It is preferred just to wear a hat.
- Legs of pants should be worn within the boot.
- The respirator and safety glasses should never be removed during sampling and analysis.

Other security methods.

- Do not eat, smoke or chew anything during the working period.
- There should always be a medical kit with alcohol or other disinfectant, cotton, bandages (various sizes), and germicide soap nearby.
- In the case of cuts, scratches or whatever other accident during the work, the wound must be washed with water an soap, then it must be disinfected and covered and if necessary, transport the infected person to the emergency room.
- Work must be done with two recollection bags, that way if one breaks during the recollection for sampling, there is another bag there to keep the waste from falling to the ground.
- When finished with the work routine of the day, one should wash and disinfect the personal protection equipment, especially gloves.
- The worker should bathe when finished with working in the eco-station.

3. Integrated managment component of ECODESS

One of the principle challenges for sustainable sanitation is in the small locations with fewer than 2,000 inhabitants, in suburban zones, and in rural areas is to find a form of sanitation that is alternative to the conventional system of hydraulic drag, whose implementation is difficult and expensive in dispersed residential areas and complex topographical and floodplain soil. The versatility of ECOSAN technology and the implantation of a mode of management, like ECODESS, constitutes an alternative to JASS or Covaps and that can manage water and sanitation and be sustainable in their environments. From the experience with the Nievería Water Association, we can recommend the following guidelines for action and implementation[10]:

Community self-managment of the system
Once the project is concluded, in agreement with the users, the responsibility of the maintenance of the system of ECODESS passed to the Nievería Water Association. This maintenance includes: collection of dry treated stool, which is done when the second chamber is full, therefore it must be done once every one and a half years, grease treatment, which should be done every 15 days, cleaning of the constructed wetland ever 6 months and the maintenance and cleaning of external networks every 6 months.

In practice, the general results have not been positive, although some of the users have responded well to the established system, the majority have not completed these recommendations so that the grease trap and constructed wetlands clog up. That is why the second phase is being organized by a communal organization to manage the service.

[10] "Nievería Water Association" is a form of community social enterprise established to manage water and environmental sanitation of the people belonging to Asociation of Owners of Water Systems, Sanitation and Environmental Management of Nievería. It is a legal person of private law and non-profit, which represents all the people associated with Associated Residents of Los Topacios in Nievería, the Associated Residents of La Huerta of Nievería, and the Associated Residents of Los Jardines of Nievería. In addition it is composed of settlers who use the water systems who are not part of the previously mentioned organizations.

3.1 Modes of business management of the service

At a general level, there exists a community management committee of the system, which is in charge of the administration, maintenance, and control of the system and also delegates authority to a subcommittee on the maintenance of green areas (assuming there is a park withing the sysem). The population associated with the business participates in the approval or rejection of the initiatives of the board, which is done through an assembly of partners. On the operation level, social participation is also expressed through the permanent care and supervision of a properly functioning system. The health sector will check on the health impact on the residents.

The management of the water system, sanitation and environment is done by the Homeowners Association of Nievería. This social community business was created to administer the system of water and ecological sanitiaton of the members of the aforementioned association, and there have been established statutes governing the functions of this role.

- Service provision of potable water, ecological sanitation, and envrionmental management

In the provision of water through networks, families of the community of Nievería control and maintain eco-toilets installed in their own homes and also the promotion and education of how to use and improve their environments through the use of the systems.

- Potable water service

Marketing of these systems of clean water is done through connections to other human settlements around the community of Nievería, these secondary connections are shared by the community. The innovation of presentation of the system of potable water, sanitation, and management of the environment of Nievería is not only characterized by the use of clean technologies (UDDTs) or the implementation of a network of potable water with its own geographical resources (sub-terranian water), but rather for the innovative way of promoting self-management of the system and local development by involving citizens and institutions for the sustainability of the system and improving the quality of life both for the families of Nievería and the surrounding communities.

3.1.1 Purpose of water service in Nievería

a) Ensuring environmental and urban quality

b) Ensure proper functioning of the system integrated water, sanitation and environment, in coordination with ecological sanitation and condominial committees.

c) Representation of entities associated with sectoral and/or central government to the municipality as well as provincial and district levels to promote and manage the physical and legal reorganization of the water system, sanitation and environment.

d) Administer the service of potabel water and sanitation.

e) Ensure the issurance and collection of receipts from services and distribute the revenue accruing to the water system, sanitation condominium and ecological sanitation.

f) Organize partners in collective or communal work that contribute to environmental improvement and implementation of the services of potable water and sanitation in the area Nieveria.

g) Promote the spirit of fraternity, solidarity and mutual assistance among its members and families for system maintenance and proper use of drinking water.

h) Manage and carry out complementation of the water works system and the system of household sanitation facilities.

i) Make agreements with public and private entities to seek advice and technical support as well as the implementation and repowering of the water system.

j) Enter into contracts of sale, lease, use and banking.

k) Manage projects to improve cooperation system with institutions, municipalities, provincial and district levels, central government, private enterprises, etc...

l) Other environmental improvements

3.1.2 Organization of the system

Composition:

- President of the Board.
- Vicepresident of the Board.
- Secretary of Acts.
- Secretary of Organization.
- Secretary of Economy.
- Secretary of Supervision.
- Secretary of the Service of Potable Water.
- Secretary of Ecological Sanitation.
- Secretary of Environment.

The Board has a Consultative Council, which convenes technical advisors from NGOs and volunteers, and through this body that assesses the proposals for development projects.

Sanitation operator

- Operate the maintenence of teh system of ecological sanitation.
- Report the results of operations to the administrator.

Water service operator

- Comply with the standards of service provision and regulation of the business.
- Maintain the water networks in Nievería.
- Providing a high quality service to client families.
- Control the mainenence of operating vehicle.
- Maintain hygenic conditions in the service equipment and y surtidor.

Environmental manager

- Educate, promote and develop good practices in the families in Nievería and the surrounding populations in order to conserve the environment. Hold environmental education campaigns with coordination with the administration.

- Fight the practices of businesses that harm the environment of the zone.
- Educate the population on the use of ecological bathrooms and the processing of obtained waste.

3.1.3 Role and functions of the Secretary of Ecological Sanitation

- Promote the work plan and respect its goals.
- Ensure proper functioning of the external networks of the system ECODESS (Ecological Sanitation).
- Coordinate wtih the board and guards to monitor the system on the inside of all homes every three months to check out its components (eco-toilet, grease trap, constructed wetland...).
- In coordination with the ecological sanitation committee, organize sepcialized technical assistance when it is required.
- To monitor the proper use of funds granted for the cost of maintenance.
- In coordination with the board, form a micro-business to supply the necessary lime and soil and clean the drying chambers.
- In coordination with the board, managing the care of the health sector responsible for monitoring the quality of ecological sanitation system.

3.2 System of recollection, treatment and reuse of excretas

According to reference the Inca Garcilaso de la Vega, in the reference made by Antúnez de Mayolo (1984), it is known that the ancient Peruvians used human waste to fertilize their soil, ... "Manure to fertilize the land, and it is noteworthy that in the valley of Cuzco, and so on around the mountain, human manure is used into which corn is planted, because they say it is the best. They tried to do with great care and diligence and we have made lean and powder when planting corn. It is called Aka izma (human excreta).

The farmers recognized that the use of crude waste water, improved the fertility of their lands because of the addition of organic material and nutrients contained in human excreta. This practice is common in the Peruvian cost, particularly in the lower basins and during the months between June and September, the period when the majority of the rivers are totally dry because they rely completely on the rainfall in the upper areas of the western side of the Andes mountain range which falls between December and May.

In the markets in the capital, lima, it is estimated that 30% of the vegetables consumed by the population are cultivated utilizing wastewater (Matos Mar and R. Matos 1990). This information is disclosed to the consumers only a precaution to remind them to wash their vegetables well before consuming them. It is a lack of this information which experts draw attention to, as in the case of Guerrero (2004), which signaled that:

"It is particularly important to consider the treatment suitable for fecal matter and the derived products from excretions (residual sludge, septic tank effluent, latrine contents, human excrements, and composted fecal materials"[11].

In this context, the principles of ECOSAN of health and recycling, gives us a pattern for developing the ECODESS as a concept of productive eco-sanitation, the same that seeks the reutilization of cleaned wastes, considers the recommendations of the established OMS in their "guide of management of greywater, excreta, and urine" (2007).

3.2.1 Management fo the dry treated excreta treated in the UDDT in the home

In the preventative aspect of management, all the security mechanisms must be exhausted in order to evade contact with the waste. It is this part of ECODESS that is considered to be of highest importance: use, cleaning, maintenance, recollection, transportation,

[11] Eng. Juan Guerrero Barrantes, Principal Professor of teh vaculty of Agronomy at the National Agragarian Universtiy, La Molina, Source: Interview 2004.

storage and treatment.

For the cleaning, when one chamber is filled, the user of the UDDT sends for the communal business to come and provide the service of cleaning and removal of the dry excreta from the chamber. In the case of Nievería, there exists personnel charged with recollection, but a few of the citizens prefer to do their own cleaning. For both cases, the following methods of security are recommended:

- Use gloves, protective clothes and dust preventing masks.
- Recollect the excreta with a hand hoe, pick, broom and dustpan.
- Collect the excreta in containers or impermiable bags.
- Place the excreta in a sercure and protected area, free of rain and humidity but it is recomended that is recieves the heat of the sun.
- Precautions should be taken in order to avoid spilling the waste on the grounds of the home.
- The waste is washed at the eco-station to prepare it for final treatment and to be recycled.

The model of management of water and ecological sanitation, ECODESS, in the suburban areas of Lima (the areas of Huachipa and Nievería) required a treatment agreement on the excretas from the UDDT. The methods for this depend on the fiscal, chemical and sanitary quality of the said results. CENCA in coordination with the Faculty of Agronomy at UNALM, completed an evaluation of a few parameters of the quality of excreta in order to create an more agreed upon method of treatment.

Photo 12: Recollection from the chambers of the pre-treated excreta

4. Awareness, training, capacity development and social development components of the project

One of the most important components that has been incorporated to the management of social projects in the last few decades is the community participation in the different phases of the process of implementation and for every process of operation, use and maintenance. This includes the phase of post-execution and is important to articulate with local promoters and competent institutions such as MINSA (Ministry of Health) or the district municipality.

This strategy is key to achieve future sustainability of the project. In the case of an innovative project, like ECODESS; it is especially necessary. This strategy was made when CENCA developed an intervention with a higher investment in the social component, developed a strategy that has as an objective the appropriation, for part of the population, of the technology of ecological sanitation.

Thus the intervention in Nievería, which includes the 83 families that form the family group, Los Topacios, constructed ecological sanitation systems in 43 homes. Now there exists in this settlement, more than 60 lots that have Urine Diverting Dry Toilets which have been constructed through self-management. This results in the ownership of the system by the residents.

As mentioned above, the social aspects that develop this type of Project have a key importance in the suitability and level of approval on the part of the population. At least the costs that are included in the social promotion, awareness, training, and the communication should be considered and budgeted. The agreement of the experienced done by CENCA determined that this expenses was found to be in the range of 12 to 15% of the total costs of the project.

4.1 Completed modes of social investment

Phase 1.- Design, aweareness and organization for the implementation

The adoption of a Urine Diverting Dry Toilet requires an exclusively voluntary decision by the user. It is important to note that the aspiration of the people in their home is to implement a conventional hydraulic drag bathroom, because that is his perception of modernity and it is difficult to reverse it. Therefore, at the stage before the start of the investment and awareness is essential to take the following steps:

- Evaluate the conditions of feasibility for the implementation of conventional services of hydraulic drag in a sustainable manner, that is to say, study the economic, environmental and geographic viability that permits the ruling out of conventional sanitation and the assuming the proposal of ECODESS.
- Evaluate if the EPS has plans of investment in that area in the coming years or if there exists a project of conventional sanitation in the works done by the work of the citizens. This is to avoid the risk of generating internal conflict and debilitating the future sustainability of the system.

For the process of awareness building, it is recommended to be more transparent and clear with explanations of the system, demonstrate the advantages and also its limitations. The decision to accept the option of ECODESS must be made collectively and done by an assembly along with acts of agreement. In the awareness building phase, the following strategies are recommended.

- Recognition by the people themselves of the problem of sanitation in their community.
- Invite leaders and community organizers of the settlement involved, to get to know experiences of composting toilets in places where they are already functioning, so they know the system ECODESS in practice.
- Give talks and develop educational materials explaining the project and the benefits of technology to be applied.
- Specify the commitments and actions to which the population engages in the implementation, maintenance and operation of the system.

In the execution of the design of the project, it is recommended to be a participatory work that includes the integrated design of the home, in which the location of the Urine Diverting Dry Toilet will be located to become part of the architecture of the building. The location of the grease trap and household constructed wetland must also be considered in a case that does not have centralized treatment facilities. In the exterior design, define the greywater collection network, its location, calculate the volume of the constructed wetland, and finally the location of the green area and its irrigation system. The organization of the benefiting population is key to ensure their participation in the completion of the activities in the execution of the project. In the experience in Nievería, a project management committee was formed in order to participate the participation of the population in the activities of awareness building and the execution of the work.

Phase 2.- Execution of the work and training

The training was led by three main groups: users, the management committee and the builders.

- The training of the users took place on two levels: a) in the collective manner, through training workshops about the general themes of caring for the environment, protection and care for fresh water and water security b) every family is responsible for their own use and maintenance of their own system of ecological sanitation.
- The training of the management committee was developed with aspects of administration for the maintenance of the external installations that they themselves will take on, as the Board of the Association of Nievería, the service of management of maintenance and use. Other trainings were undertaken to strengthen organizational skills in order to build values of reciprocity, teamwork, transparency and accountability and proper relations between neighbors and leaders.

Regarding the training of master masons and/or plumbers from the area for the process of construction of UDDTs in Nievería, they were taught to apply a strategy for which they gained knowledge in the constructions of the bathrooms for them will be used in future maintenance and were charged with expanding and improving the system. This training has permitted new families to the settlement to contract with these masters their own construction of UDDTs and now if any flaws are found, they can also make repairs.

In general, the method of training includes application of previous knowledge, the strengthening of the knowledge of this, the dynamic participation that generate a suitable environment for the training of lessons and skills.

Phase 3.- Tracking, monitoring and evaluation

The Association, Los Topacios, is the first community in Nievería where a project of the environmental court (ecological sanitation) has been executed. This has helped turn it into a window that reflects ecological sanitation as a healthier and more sustainable option for the community. Now they have executed similar projects in the surrounding communities. Therefore, the Association, Los Topacios is today one of the more visited communities in the general public for their functioning understanding of UDDTs. The families themselves are able to explain the advantages and how it works.

The replication of this project in the zone has permitted to be a constant closeness to the association. They continue to do works in the area and have made it possible for regular visits of the UDDTs of Nievería. This permanent contact has contributed in the solution of a few problems that have presented themselves in the use of the UDDTs and have reformed at the same time the knowledge of the users. This is also one of the most advanced ECOSAN experiences in Latin America and therefore there have been numerous national and international visits.

4.2 Perceptions and comments by the users

Through focus groups conducted with users has taken up the following impressions:

- The people demonstrate great satisfaction about the use and benefits that the system provides. Although, many initially had some difficulty or fear of using it, it was eventually adopted with satisfaction. Now they are the ones who teach their visitors and/ or relatives the use of composting toilets, showing that it is easy to use not only for adults but also children. They also argue that it has improved the image of their homes and thus the self-esteem of each family member.

"…in my case, I had to go to the field, bush, or out at night like an owl. When I was given an ecological sanitation system, for me it was joy and has really been unforgettable, so far I´m still enjoying it…" (Juan 54 years)

- Although they see the importance of involving families in the choice of ecological sanitation systems. Many have proposed upgrading the bathroom, in order to reduce the need for human participation in its maintenance.
- They emphasize a lot the value of the training, especially the module called "housing accommodation", which involved all family members.

"... I believe that all training is very important, and we had skilled people, but without it we would not have been put to good use to the bathroom because no one in this area had used it before ..." (José 40 años).

- There is a strong and clear support to the alternative which is ecological sanitation and many see it as an opportunity to improve their quality of life. Through a research example, they say that if they moved homes and areas, but continue with the ecological toilet. The vision we have to respect is that in ten years, its operation will be satisfactory, and more modern.

"... I see my bath here ten years working in perfect condition, with important finished improvements and a more comfortable situation..." (Juan 30 años)

5. Productive and economic component of ECODESS

The economic aspect is not only expressed with the administration of just charges, that fundamentally permits, the service to be provided with economic sustainability, but on the concept of productive eco-sanitation, which is understood as the promotion of local investment in the system implementation. This promotes local employment and economic activities through local micro-enterprises related to:

- Technical assistance in ECOSAN.
- Production inputs such as the drying material, parts and accessories.
- Recollection of dry treated excreta and urine from the homes or collection centres and transfer to storage centers, processing plants or the eco-station.
- Maintenence of a household and neighborhood system of ecological sanitation, grease traps, and constructed wetlands.
- Comercialization of related products such as organic fertalizers, agricultural fertalizers from urine, drying material and treated water for irrigation.

5.1 Service costs of Ecological Sanitation

- Make evident the need for a usage price through practical examples, i.e. assess the quality of the UDDT in the area where maintenance is not adequate.
- Participation in workshops to determine costs and expenditures, those that are permitted to debate about the prices of the necessary machines, equipment, inputs, interest rates and the moratorium, which MET compared with a benchmark of banks or municipal cash and personal loans that are made in the area.
- Popular agreement, through the assembly, the rate of use of ecological sanitation was established. In this regard it has become clear that there is resistance in the administrative processes of the organization, but involves sustained management to undertake costs that many still fail to be recognized. This has meant delays in the time of the tariff structure, however, yielded an appropriate fee to the needs of users who allow their sustainability. It must be mentioned that here with respect to the majority of the JASS systems, cost is an issue. There will exist people who do not want to pay the tariff and thus it is necessary to develop an oriented strategy that takes them into account and demonstrates the need to pay for the service, especially in alternative sanitation systems like ECODESS.

5.1.1 Method of Calculation

Our methods are focused on the components of the system, such as: the engineering of the project, materials, team, human resources, and administrative costs. Thus is discovered the capacity to pay, the principal economic activity, and the behavior of the user..

Greywater network-
The completed analysis for the network components was considered in the operation that is dedicated to complete the cleanings every 3 months. For this it was necessary to count with a WINCA, thus with external operative help, the special services were contracted. As for the administrative support, they required office supplies for the corresponding coordination.

It was calculated that the maintenance took approximately 40 minutes for every 40 linear meters of installed network. It was said that in order to complete the general maintenence, about 14 man hours were used.

Table 3: Calculating costs of netwokr maintenence

Networks						1.71
Operators ¼	MO	1	85	60	1	0.71
Wincha	GLB	1	85	120	24	0.06
Other	GLB	1	85	20	1	0.24
General admin.	GLB	1	85	60	1	0.71

Grease trap.-
For the grease traps, the cleaning needed to happen every 15 days. This demand for resources is reflected in the table below. It is estimated that it would take personnel about 7 minutes to clean each grease trap. Therefore in one day, of 8 hours, approximately 76 grease traps could be cleaned.

Table 4: Calculated cost for maintenence of grease trap

Grease trap						1.76
Sacks	GLB	2	85	0.3	6	0.10
Gloves	GLB	1	85	7	6	0.01
Operator 1/4	GLB	1	85	60	1	0.71
Others	GLB	1	85	20	1	0.24
General Admin	GLB	1	85	60	1	0.71

Constructed wetland.-
Cleanings should happen every 6 months, maintenance is only considered with costs of operator and the administration. This responds to the process of validation of the tariff. In a meeting it was agreed that the rocks and plants the residents would buy regardless, this is why single component costs and expenses mentioned below.

Likewise, the maintenance demand an average of 3 hours per household, or an average of 3 households per day.

Table 5: Calculated costs for maintenece of constructed wetland

constructed wetland						1.41
Filtering plants	GLB	20	85	0	6	0.00
Crushed stone	M3	0.25	85	0	12	0.00
Operator 1/4	MO	1	85	60	1	0.71
General admin.	GLB	1	85	60	1	0.71

Excreta drying chambers.-
According to the recognized data from the users, the change of drying chambers happens every year. The operator works this component with the demand of each home and with the date that the user indicates. The time that is necessary for an operator to do this is approximately 30 minutes per chamber and thus about 16 homes per day.

The indicated resources in the table are necessary for the opening and sealing of the door of the chamber, which permits the removal of the excreta in order to convert it to drying material. It is necessary to use gloves and bio-security equipment in order to cover the safety requirements in these cases.

All components have administrative costs and depreciation of infrastructure.

Table 6: Calculatino of costs for maintenece of the chambers

Excreta drying chamber						2.10
Lime	KG	10	85	1	1	0.00
Soil	KG	40	85	0.1	1	0.00
Masks	GLB	2	85	4	1	0.09
Gloves	GLB	1	85	7	6	0.01
Hand truck	GLB	1	85	400	24	0.20
Pallas	GLB	1	85	35	12	0.03
Plaster	GLB	1	85	0	12	0.00
Operator 1/4	GLB	1	85	60	1	0.71
Other	GLB	1	85	30	1	0.35
General Admin.	GLB	1	85	60	1	0.71

Ability to pay - average income by classification.

- Labourer = S/. 15.00 soles daily.
- Bricklayer = S/. 25.00 soles daily (Eventual).
- Employee = S/. 20.00 soles daily.

- Foreman = S/. 30.00 soles daily.
- Others = S/. 100.00 soles or more.

5.1.2 Billing

Basic income.
This is considered to be an important component within the billing structure because when one reflects the project costs, comprised of fixed costs and depreciation for the present case with consideration to the costs of investment in the compost chamber, constructed wetlands, grease traps, etc..

Maintenence serivce.
The maintenance services reflect the variable costs, which are always changing due to the demand and the prices on the open market. Understand these costs and direct costs of the maintenance services, labor and key inputs to meet the exigencies of service..

Late fees.
It is the increase of value which includes a benchmark interest due to delayed payment of a debt.

Monitary interest.
There are proceeds that are generated by a payment that was not done on time. The moratorium interest rate is usually applied to commercial purposes, personal and also apply the civil service where the taxpayer is late in paying their obligations.

We want to indicate that at the time of publishing the present document, in Nievería there has not been implemented this tarrif because the resistance of some in the adoption of higher tariffs in general meeting, has made an agreement impossible, the argument holds that it is related to malicious prejudice that someone will benefit from the increase and therefore promotes idea that each family will sustain itself. It is true that at first it works, but the medium-term ineffectiveness has been record evidence. That is why part of the directive and with the support of CENCA has launched a pilot project financing and maintenance services linked to the marketing of drying material to the UDDT.

Table 7: Monthly billing per home in the system

Billing	
Basic income	5.66
Depreciation	0.27
Administrative costs (10%)	0.57
Late fees 5%	
IGV	
Sub. Total	6.49
Utility (10%)	0.45
Total	6.95
Rounding effect	0.05
C.U. ECODESS	7.00

5.2 Comercialization of drying material

This product was born from the evident need that the families had with Urine Diverting Dry Toilets that required a combination of soil and lime for the evacuation and coating of excreta after each use of the service. Every family took lots of time to make their own drying material which composed of buying lime, finding the dirt, sifting, and then combining these parts. In some cases they did not achieve the necessary combination due to an absence in the material in the area and therefore the new product is produced according to the needs of consumers of Nievería and those of ecological toilets in Peru. But this also creates a more uniform drying material and thus guarantees adequate sewage sanitation.

According to a survey developed and executed by CENCA and Water Managers Nieveria and given to 20 families that have the UDDTs, yielded the following results:

The table shows clearly that there is great difficulty in the preparation, because no lime or enough soil, and you have to go out and get, often late at night and the lack of time for sifting.

Fig. 11: Ease of preparing the dirt-lime mix

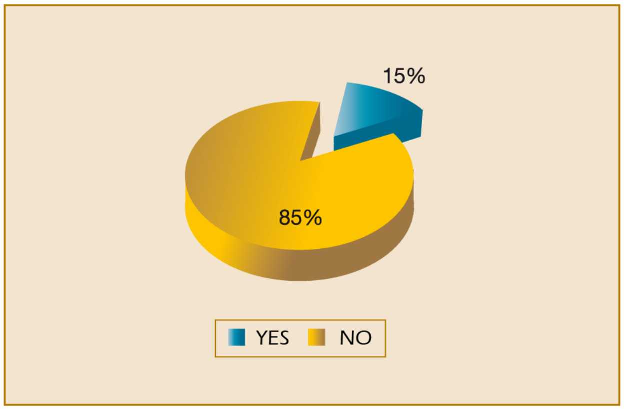
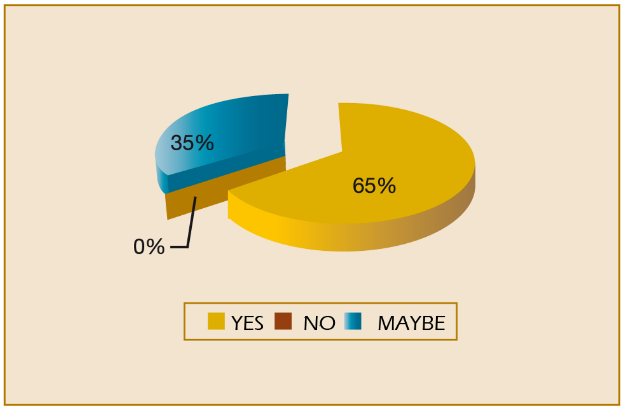
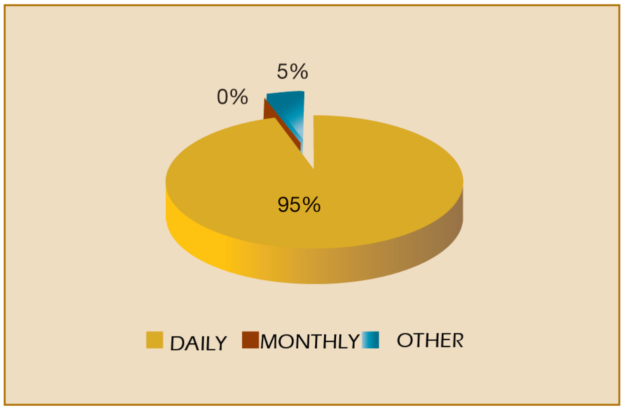


Fig. 13: If a mix of lime and dirt was offered, would you buy it?



The daily purchase 95% to a value of 0.50 cents per kilo, followed by a 5% that is done monthly.
The table shows that 65% would accept a mixed product and the reason is obvious: time. 35% answered "maybe" because they prefer to know first what the price and quantity of premix.

Fig 12: How often do you buy lime?



For this reason we have designed two products drying material: recycling and new, for sale to the public .

- Recycled dry material, Is the material that is made of the final product of treated dry excreta and then sold. The recollection is done by hand, by an operator who has all the safety equipment. The waste is collected in bags of about 50 Kgs and is carried to the eco-station, where it will go through the selection process in which, after evaluation of quality, they are scored and subjected to a process of rest, if necessary.

- According to the tests carried out by DIGESA, waste of more than 6 months in the chamber does not contain pathogens or viable egos. However it is recommended to take an additional 6 month rest, later the apt material is sifted and put in the sun for 7 to 10 hours, depending on the temperature and is laid in areas with a surface area of at least 8m2. The material is later turned and then one can see how the interior parts still are wet. A continuation of the process of mix with lime with a relation of 4 to 1 for after it dried and packed. The process ends with storage of the products and then sale of them in the stores of the area.

5.2.1 Cost structure of drying material.

The determination of the prices is done through the means of a democratic process of communal evaluation in which, the future user sees every cost that is necessary and in the accepted structure the price of sale for the benefits obtained.

Photo 14: Preparation of drying material

Photo 15: Drying material for sale

The Water Association of Nievería has put, as a type of pilot plan, the sale of recycled material as drying material in 10 kg packets, but also they have other products that have been called new drying material.

Table 8: Drying material prices for sale

Concept/Presentation	5Kg	10Kg	20Kg
Direct Costs	1.20	2.40	4.81
Utilities	0.30	0.6	1.20
IGV	0.29	0.57	1.14

Table 9: Cost structure for UDDT drying material

Drying material	Unit Price	Quanitity	Unit	% Price	Annual costs
Soil – bathrooms	0.1	4	KG	0.083236224	1440
Lime	0.5	1	KG	0.416181122	7200
Paper bags	0.2	1	MILLAR	0.166472449	2880
Scales	0.0174	1	GLB	0.014483103	250.56
Bag Sealers	0.007	1	GLB	0.005826536	100.8
Mesh sifters	0.008	1	METROS	0.006658898	115.2
Personnel	0.3	1	RH	0.249708673	4320
Water	0.026	1	M3	0.021641418	374.4
Electricity	0.043	1	KWS	0.035791576	619.2
Local rent	0.15	1	MES	0.124854337	2160
Unit price x 5 kg packet	1.2014				
Unit cost x 10 kg packet	2.4028	Note: it was observed that prices fluctuate during the 12 month period, which is beneficial for the company that is a period to recover its assets.			
Unit cost x 20 kg packet	4.8056				

In the same way, tests of a financial mechanism of the bathroom service maintenance have been done. This is to increase the costs of drying material, maintenance, which provides collection services and maintenance of ecological bathrooms by the accumulation of 10 packets of drying material of 10 kg. The cost of the two products, the recycled drying material and the new packets is as follows:

Table 10

Concept/Presentation	Recycled 10Kg	New 10Kg
Direct costs	4	5
Utilities	1	1.25
IGV	0.95	1.1875
Total cost in Nuevo Soles (S/.)	5.95	7.4375

5.3 Direct costs per unit for the implementation of a UDDT

The direct cost of the installation of the ecological sanitation infrastructure in Nievería was aproxamently US $603.00 per house. This amount included the prices of the eco-toilet, the double chamber storage and drying unit, the urinal, the sink, the domestic treatment system (grease trap and mini constructed wetland), and installation of the interior and exterior networks. The basic stall, that is a stall made of bricks with a shower, without exterior coating or finishing, of approximately 4m2, but it should be noted that in its construction, the population them with unskilled labor.

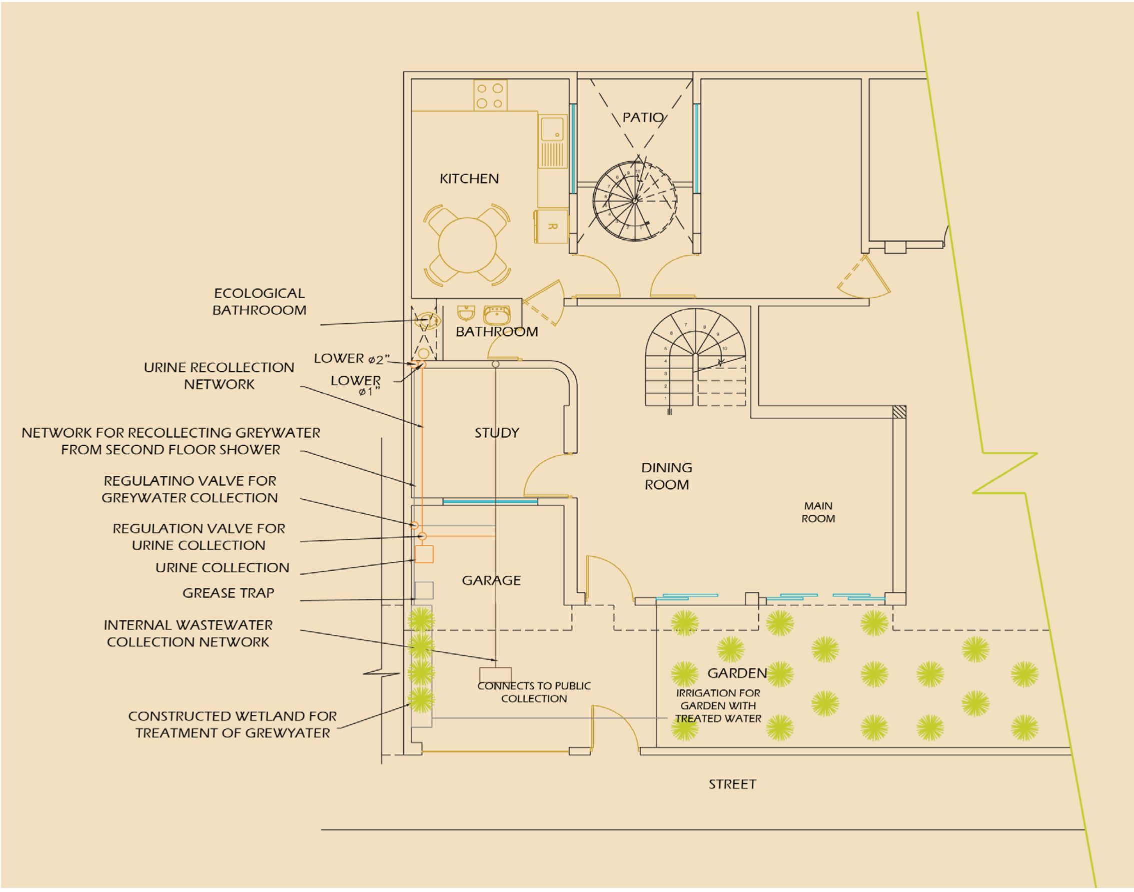
6. Lessons learned and recommendations

In Peru, in the last few years, there has been developing interventions with an ECOSAN focus such as alternative technologies that solve the problems that infringe on the environment and health. Some of these cases destroy green areas, destabilize slopes, increase floods, generate more black water and destroy water sources. It is important to realize that the ECOSAN experiences, with the purpose of bringing proposals in line with interventions, which can also become themselves valid proposals, for the local governments in rural, suburban, and urban zones. A continuation details a few of these proposals with the focus to generate discussion, better knowledge and favorable legal situations in order to replicate these paths.

6.1 Contribution of ECOSAN to reduce black water

The integrated design of the home with an ECOSAN focus assumes the basic principle of ecological sanitation and at least its design should consider installations and infrastructure to transfer, store, treat and/or reuse internally or externally the domestic organic residues (greywater, urine, and dehydrated excreta) in a separated manner. The basic components of an ECOSAN home are:

Fig. 14: House plan



- For greywater:
- Internal sanitary instalations that recollect the greywater from the sinks and showers from each of the bathrooms within the home.
- Sanitary instalations for the recollection of greywater from the kitchen and washing machine.
- Recollection networks that brings all the greywater from the houst back together.
- Infrastructure to separate grease from the household grease trap.
- Constructued wetland for the treatment and reuse of greywater as irrigation for the green areas of the home. This is calculated based on the flow of produced greywater.
- Regulation valve that premits the evaucation of the system to an exterior collection system for unnecessary greywater.

- For urine:
- Internal network for the UDDTs to capture urine in from the eco-toilets and urinal.
- Internal collection network to recollect all the urine from all of the UDDTs.
- Urine storage tank made of plastic in order to sseparate the necessary urine for internal use in the house on the green area.
- Regulation valve that permits the evacuation of unnecessary urine to an external collection network.

- For excreta:
- Separating eco-toilet for excreta and urine.
- Storage container for the excreta within the area of the storage chamber.
- Collection container for the excreta and the drying material.
- Tranfering duct to aid in the movement of the excreta from the container for the UDDTs located on upper floors.

In order to accommodate to female users of UDDT, the eco-toilet has been designed with a mechanism to closer the container, converting it into a urinal that does not permit one to see the waste.

6.2 UDDTs adapted to all home environments

The Urine Diverting Dry Toilet with two chambers applied in Nieveria (and that already applied in diverse cities around the country, such as Santillana, Ayacucho, Papayo in the mountains near Piura or Moyobamba, the central jungle and other areas), one can also add the one chamber ecological bathroom. Its application is recommended when there is reduced space or when there will be use of a chamber (a movable receptacle where the excreta is confined) in place of a storage chamber. The advantage of this design is that it reduces the work of recollection because one only has to switch out the container when it is full for another. Thus the costs of the service are greatly reduced. It is recommended that the capacity of the container be no more than 100 liters so that it can easily be changed ever 3 months. This design has been applied in the Constant Inlet at the beaches of Piura, in the AAHH San Francisco in Nievería, lima and in a provisional or emergency manner in the area affected by earthquakes in the city of Pisco.

Photo 16:

UDDT in Santillana, Ayacucho. It was completed with a double chamber with a shower, urine capturer, constructed wetland and was done by Health Without Borders, Peru with help by CENCA and ITDG

estimated cost

US $630.00

There is great flexibility of design that comes with the diverse types of eco-toilets. These will be chose depending on the user´s criteria and will depend on ease of use and customs. As such there are the shell type, recessed type, and the type from floor level which is used often in China where the custom of defecating seated does not exist.

Photo 17

Horizontal floor eco-toilet.
Material: Fiberglass
Unit cost: US $40.00 .

6.3 Reuse of excreta as a drying material

The form of preparation of the drying mix that will be used for the eco-toilets was variable between the using families. A few of the families use the same proportions of soil and lime for their drying mix, but others only use live lime. The composition of the drying mix does not affect the pH, the electrical conductivity, the bulk density, nor the organic or nitrogen contents that make up the final maturation process (see table n. 1), but the application of lime without soil in the drying mix increments the final percentage of calcium carbonate ($CaCO_3$) produced as waste, that which is related to the higher capture of CO_2 for the lime, in relation to the relations of both.

The largest final content of calcium carbonate (CaCO3), could favor cementation and compaction of the waste in the chamber. The incorporation of soil in the drying mixture produces a higher release of carbon dioxide (CO2) into the air, reducing the final weight of the residue in the chamber, and allows reuse in preparing new mixes.

Table n. 11: Effect of the porportion of soil and lime in the eco-toilet mix

Porportion of lime and soil (%)	pH	Electrical conductavity (dS/m)	Bulk density (Mg/m^3)
0:100	7,26	12,58	1.04
40:60	7,28	13,40	1.13
50:50	7,37	8,93	1.12

Source: own research

There are no major differences between the various proportions of soil and lime used on the characteristics of the final residue (see Table 2), so that the proportion suggested by CENCA (three parts soil to one of lime) is recommended by be less costly.

Table n. 12: Effect of the porportions of liem and soil in the drying mix

Porportion of lime and soil (%)	C organic (%)	N total (%)	$CaCO_3$ (%)
0:100	0.8	0.21	21.42
40:60	0.8	0.31	12.86
50:50	0.7	0.21	12.38

Source: own research

Physical-chemical analysis
The samples obtained from chambers of waste indicated a density ranging between 0.98 and 1.27 mg/m3. These values are similar to the soil and drying material prepared, indicating a high degree of decomposition of excreta.

The application of live lime with the drying mix gives as a result, a marked increase in pH in the residue, with values above nine, which was enjoyed until three months after completion of the accumulation of excreta (see Table 3). In the following periods of the sample, it was demonstrated by a decrease in pH of the material, stabilizing at values of seven to eight, those who remained within that range during the remaining term of maturity. The decrease in pH may be related to CO2 capture reaction by mixing desiccant lime, a situation that would occur during and after filling the chamber eco-toilets. The maturation time of the residue also affected the electrical conductivity of the material, since during the first three months of maturation observed that this was low, however, increased in the following sample remained at values close to 10 ds/m for the remaining term of maturity. This increase may be associated with a higher degree of mineralization of organic residue, indicating that the decomposition occurred during the ripening process.

The maturation period also showed no effect on the final content of calcium carbonate (CaCO3) as the final residue weight had values ranging from 10.0 to 12.4% from three months of maturation, suggesting that the capture CO2 released by the oxidation of organic matter occurs primarily during the first months of the process. After six months of maturation, the stool continues mineralized, but it is possible that the CO2 is released outside the chamber in gaseous form.

Photo 18: Recolection of samples

Table n. 13: Effect of time on the maturation of the physical and chemical properties

Grade of maturation	Time of maturation (months)	Apparent density (Mg/m^3)	$pH_{(1:1)}$	Electrical conductivity (dS/m)
Fresh	3	1.27	9.26	2.85
	6	0.98	7.15	10.58
Intermediate	9	1.24	7.27	10.05
	12	1.08	7.17	10.76
Mature	15	1.15	7.63	10.61
	18	1.03	7.39	8.91

Source: Analysis done at the soil laboratory at the National Agrarian University la Molina

The organic carbon content in the residue of eco-toilets showed very low values, which varied from 0.4 to 0.7% (see Table 4). These values point again to a high rate of carbon mineralization of excreta from inside the chamber. Most of the captured carbon remains in the form of carbonate. The organic carbon was not affected by the period of maturation within the chamber, indicating that the mineralization occurs from the beginning of the maturation process.

The total nitrogen content in the residue is also low, because it has values between 0.15 to 0.28% (see Table 4). There was no influence of time of maturation of stool in the total nitrogen content of the waste. The low values also indicate a high mineralization of nitrogen excreted, however the C / N in the residue (2.5:1 to 3:1) suggests that unlike the carbon, most of the mineralized remains in the residue, possibly in the form of nitrate (NO3-)

ⁿ Microbiological analysis

Microbiological testing of waste samples showed very low values for the populations of total and thermotolerant coliform bacteria, as well as Escherichia coli and Salmonella. The values found were below the detection limit for the method of most probable number (MPN) for all sampled maturity periods from three months to twelve. (see Apendix 9.1)

Table n. 14: Effect of time on maturation with respect to physical and chemical properties of pretreated dry excreta.

Grade of maturation	Maturtion period (months)	$CaCO_3$ (%)	C organic (%)	N total (%)
Fresh	3	10.0	0.6	0.23
	6	11.9	0.7	0.28
Intermediate	9	11.4	0.7	0.16
	12	11.0	0.4	0.15
Mature	15	10.5	0.6	0.21
	18	12.4	0.5	0.17

Source: own research

These results suggest that rapid mineralization of excreta is associated with disappearance of coliform bacteria and pathogens, thus cleaning up the waste in the chambers of eco-toilets can be achieved after three months of maturation.

We did not detect populations of intestinal helminthes and protozoa in the samples of waste at any time in eco-toilets during the maturation process of the residue (see Table 4). This indicates that adults,

Table n. 15: Effect of tiem on the maturation of pathogenic and paracitic bacteria populations in pretreated dry excreta

Grade of maturation	Period of maturation (Months)	Total coliforms	Thermotolerant coliforms	Escherichia coli
		(NMP/100 g)		
Fresh	3	< 1.8	< 1.8	< 1.8
	6	4.5	< 1.8	< 1.8
Intermediate	9	< 1.8	< 1.8	< 1.8
	12	< 1.8	< 1.8	< 1.8

Source: Analysis done at the laboratory of DIGESA

eggs and cysts are not viable after three months of maturing of the residue, which would confirm the dehydrating effect of the application of lime in the mix drying, which can cause death of the parasites within the chamber. The finding is of paramount importance, whereas in previous studies by Emory University on "composting toilets" in El Salvador[12] the results are different.

These results suggest that the system of disposal of excreta through the dry ecological toilet, provides an effective alternative for the elimination of potentially polluting, producing an inert waste, with low organic content, biologically stable and without the presence of pathogenic bacteria in helminthes, or other intestinal parasites.

[12] Guidelines for the Safe Use of Urine and Faeces in Ecological Sanitation Systems, Caroline Schöning and Thor Axel Stenström, Swedish Institute for Infectious Disease Control (SMI) (2007)

Table n. 16: Effect of maturation time on the pathogenic and parasitic bacterias that exist in the pretreated excreta from the eco-toilets

Grade of maturation	Period of maturation (months)	Salmonella	Protozoa	Helminths
		(org/100 g)		
Fresh	3	Absent	0	0
	6	Absent	0	0
Intermediate	9	Absent	0	0
	12	Absent	0	0

Characteristics of the results

- The residue obtained from ecoinodoros presented properties similar to those on earth or inert substrate, showing a high content of calcium carbonate ($CaCO_3$) caused by the capture of CO_2 from the decomposition product of excreta.

Photo 19: Layers of safe material in the chamber

- There was no effect of a maturation period on the physico-chemical properties of waste, except in the case of pH, which was high in the first three months of maturation.
- The total contents of organic carbon and nitrogen were very low in ecoinodoros residues, demonstrating a high mineralization of carbon from the excreta. However, the C/N ratio, suggests that while a significant fraction of carbon is released as CO_2 out of the camera, most of the nitrogen remains within it, possibly mineralized in nitrate form.
- The populations of pathogens (total and thermotolerant coliform bacteria, enteric bacteria, protozoa and helminth parasites) reached undetectable values from three months of maturation of the residue, indicating that drying the mixture is effective in cleaning up the stool.
- The combination of dry soil and lime into the mixture in 3:1 ratio drying the mixture appears to be more advisable to avoid the formation of excess calcium carbonate and matting of the residue.
- According to the results, a maturation period of three months would be sufficient to achieve the goal of decomposition of excreta and sanitation of the residue of ecoinodoros, a period of six months is recommended however, for the total neutralization of the lime in the waste and reducing the pH to levels suitable for recycling.
- The physical, chemical and microbiological waste from the eco-toilets, make it unsuitable for recycling strategy through a composting process. The residue still safe and inert. However itcan be used as drying material, previously milled, and sieved, and used in combination with lime.

6.4 Potential use of urine from the eco-toilets in the ECODESS system

Urine is a waste product of metabolism of most animals. Part of the nutrients consumed during feeding are removed through it. Fresh human urine is a rich source of nitrogen, phosphorus and potassium. The main form of nitrogen in urine is urea, which represents more than half of the dissolved solids in it. These contents make the urine in an interesting alternative to provide nutrients to plants through their application to soil or irrigation water.

ⁿ Bio-chemical reactions of urine

ECODESS In the system, the urine is separated from the solid excreta and stored in tanks or containers. The fresh urine usually has a slightly acid reaction and high electrical conductivity, due to its high content of sodium chloride, which can reach levels of 10.0 g/L (see Table 17). At this stage, urine presents its highest nitrogen content and its smell is hardly noticeable.

Photo 20: Recollection of urine from a home in Nievería

For its application in agriculture, we recommend using fresh urine, thus taking advantage of its nitrogen content. Some authors, however, recommend the fermentation of the urine to increase pH and remove potential pathogens. Under aerobic conditions, heterotrophic bacteria favor the hydrolysis of urea which suffers from the action of urease, an enzyme that splits the molecule of urea into carbon dioxide and ammonia, which can form ammonium carbonate according to the chemical reaction:

$$(NH_2)_2CO + 2H_2O \rightarrow (NH_4)_2CO_3$$

The formation of ammonium carbonate [$(NH_4)_2CO_3$] increases the urine pH, while ammonium and nitrate ions produced, increase the electrical conductivity, as shown in Table No. 17.

The increase in pH can, however, increase the formation of ammonia in the urine. The formed ammonium carbonate salt is unstable and can decompose aerobically in the urine, its component gases by the reaction:

$$(NH_4)_2CO_3 \rightarrow 2NH_3 + CO_2 + H_2O$$

The volatilization of gaseous ammonia (NH_3) causes the loss of nitrogen and cause the strong odor that is perceived in the fermented urine. A significant part of nitrogen (and thus, the fertilizer value of urine) is lost during fermentation (see Table 17).

To prevent loss of ammonia volatilization is to conduct the fermentation of urine in sealed tanks containing air, but not directly ventilated.

Table n.17: Physical-chemical characteristics of fresh and fremented human urine (two months)

Chararacteristics	unit	Fresh urine	Fermented urine
pH	---	6.50 – 6.90	9.2 – 9.34
Electrical conductivaty	dS/m	17.0 – 20.0	23.9 – 29.6
Total nitrogen	g/L	10.0 – 12.0	5.5 – 5.6
Total phosphorus	"	1.0 – 1.2	0.25 – 1.0
Total Potassium	"	n.d.	0.93 – 1.5
Total sodium		3.9 – 4.0	n.d.
Urea	"	24.0	n.d.
Amonia	"	0.7	n.d.

Source: CENCA - UNALM

ⁿ Application of urine

Urine can be applied directly to crops on the soil surface or dissolved in irrigation water. Since the electrical conductivity of the urine is high in the first case, lower dosages are recommended. The application of urine diluted with water in ratios of 1:1 to 1:5 is recommended when working with sensitive species.

The amounts needed will depend on the demand for crop nitrogen, which can vary widely. The use of urine (fresh or fermented) can replace the input of nitrogen fertilizers, which have increased their costs significantly since the previous year.

Photo 21: Storage of urine at the eco-station

Since nitrogen is the element contributed by the urine, partial contributions of phosphorus (P_2O_5) and potassium (K_2O) for the crops are expressed as a percentage of the total required (Table No. 17). The application of urine can cover between 7 and 45% of the needs of phosphorus and between 6 and 40% of demand for crop potassium, which means the added advantage of reducing the need for chemical fertilizers on crops.

Making a comparison of investment costs of urea for a hectare of land and its equivalent in nutrients from urine, the latter reduced by approximately 40%, the cost in crop production, without considering the environmental impact and profit of organic fertilizer on the ground. The challenge is how to teach farmers to start using it. It is likely that demand for organic agricultural products, the shortage of phosphorus and the rising cost of urea will aid the decision.

Photo 22: Technician from CENCA, doing tests on the application of urine at the laboratory of UNALM

6.5 Reutilization of greywater in urban irrigation

If we reuse the water from the sinks and showers, we get an average of 50 lts/person/day, which means the production of 250 Lts/day in a family of five. If gray water collected from a condominium of 60 families can get enough water to irrigate a hectare. This indicator shows the enormous advantage of a decentralized greywater treatment to solve the shortage of green areas in Lima and avoid trying to follow the treatment "at the end of the tube."

In this regard, starting from the Ecosan concept, using separate systems for wastewater collection, we recommend the application of two systems for greywater treatment using constructed wetlands. That way the first floor, decentralized household level, is to treat the wastewater from a dwelling and its subsequent reuse or dumping. This case has been described in Nieveria experience. The second centralized community level, for irrigation of green areas of a public park. A case study is the experience of Oasis Villa at Villa El Salvador-Lima ECOCIUDAD developed by the NGO. One of the main lessons learned in such systems is the ability to organize a good system of management and maintenance that can be public or communal.

- Centralized treatment plant

The proposal considers communal greywater capture of 60 homes through a sewage system condominium. The waters will be conducted at a treatment plant on wetlands or bio-filter, installed in the public park. The system should have the following units:

- Household grease trap chambers (in each home before being collected in the neighborhood storage network).
- Sedimentary tank before the water enters the bio-filter.
- Horizontal flow subsurface wetland.
- Cistern to store the treated water.
- Disenfection system with bleach to guarantee the quality of the water for irrigation.

The volume to be treated water corresponds to the order flow to irrigate a park estimated area of 1 Ha. Considering a water depth of 4 mm and implementation of a weekly irrigation requires a volume of 40 m3 per week, which could be stored in a tank of 15 m^3, whichever irrigation areas in different shifts.

It is estimated a contribution of 50 gallons of greywater per person per day:

- For a family of 5 members will get 250 liters/day.
- For the 60 homes will be 15.000 liters/day.

- Details of the constructed wetland

Average flow of greywater: 0.17 l/s
Ratio schedule: 1.8
Treatment Flow: 0,31 l/s
DBO_5 entering: 250 mg/l *
Bedding material: heavy sand
K_s granular material: 800 m/day
Porosity of granular material: 35%

* Mean values in assessment in Ecocity Project.

In the case of San Juan de Lurigancho, one of the more populous districts and atmospherically contaminated by gases from cars, factories and dust, with a population of approximately 800,000 inhabitants and an average of 1.2m^2/person requires around 600 hectares. to meet the standard of landscaping 8m^2/person. Although no provision has that amount of green areas, forests and we can stabilize slopes and water parks with gray water collected from 180,000 inhabitants is ie less than a third of the population. See how.

- In the schools

We also have the example of the experience gathered by CENCA, school 1267 - "The Countryside" Cajamarquilla - Lima, where the gray water reuse, face and hand washing of children, these waters are treated with a grease trap and constructed wetland system and are used in the irrigation of ornamental trees. Most state schools in populized areas are uncultivated areas and sinks flow to the sewage collection network. The experience made by CENCA, recovers 500 liters per day from the laundry that are irrigated with at least 20 trees.

To promote this type of experience, it is important to move forward with the development of standards. In this regard there was a history of bio-filters Workshop, held in August of 2007 at the Universidad Nacional Agraria La Molina, which was developed with the objective of sharing the different experiences in the country and promote a process that generates a standard its implementation as national policy for wastewater treatment. This rule should be included in the National Building Regulations approved by the MVCS.

6.6 Eco-sanitation products and the sale of drying material

The ecological sanitation is a component of ECODESS, dubbed by many as the "Drainage system of the future" which, in addition to reducing water consumption, allows the user, through a community management, to generate resources.

A concept we have been promoting in this sense, is "productive eco-sanitation" which involves converting the waste into an input sanitation, which, once healthy, can become a commodity. It can promote gray water can be reused in urban irrigation, urine that can become healthy fertilizer, and excreta in compost or drying material.

Photo 23: Reuse of greywater in tree planting at school no. 1267, Cajamarquilla

This last case, the company has assumed as Nievería Water the role of preparing a marketing plan where the goal is to generate revenue through the marketing of the drying material from the UDDTs.

6.7 Incorporation of the criteria of ECOSAN in national regulation building

The criteria to be proposed are based on systems focused on meeting the environmental and social needs and improve quality of life of the country with a long-term perspective, a situation that, as proposed, would reduce wastewater. This proposes implementations of innovative and sustainable projects that respond to the impending problems of the freshwater crisis. Therefore, regulation is needed to assume that the integrated water management should not only reach the wastewater treatment but also viable technologies that allow the reuse of these, with appropriate plumbing designs, from home, for their segregation.

6.8 Cost benefit analysis of Urine Diverting Dry Toilets

Comparative economic analysis of the UDDT and dry latrine are made in a national context that prioritizes conventional treatment systems and disposal of wastewater at the expense of other lower cost systems that fit Peruvian situations. As there are more 700 locations fall within the population range from 2,001 to 30,000, and is estimated to live about 4 million people live in these conditions. Unconventional solutions that require a capital cost much lower than conventional systems are feasible solutions, such as the Urine Diverting Dry Toilet made in Nieveria and dry latrines design that FONCODES is applying in their projects.

In Nieveria that is where the UDDTs are located, 40 units were installed and the evaluation was conducted over a period of 10 years. For this purpose, we took into account two scenarios, the first one considered all costs, i.e. the pre-investment, investment and operation and the second considered only the operating costs for that, two financial categories: Net Present Value (NPV) and Cost Effectiveness Index (EC), this analysis we can conclude the following:

- The total investment considers pre-investment costs, investment and operation. The total investment in the UDDT is higher than that realized by the dry latrine, S/.204,806.70 in the first compared to S/. 119,268.90 in the second. In the case of dry latrine investment house believes reruns due to the change of location of the latrine.
- Operating costs of dry ecological toilet, in 10 years of operation amount to the sum of S/.100, 924.40 and costs of operation of the dry latrine amounting to S/. 114,000.00
- The NPV of the pre-investment, investment and operation of both systems, results in a NPV amounting to S/.205, 724.19 for the case of UDDT and S /. 81,032.53 for the dry latrine.
- The index of the cost effectiveness of total investment ECOSAN system results in a cost per person S/.1,028.62 and the dry latrine, of S/. 405.16, much lower than the dry ecological toilet.
- In the event that only consider the NPV of the operation in both systems, resulting in a NPV of operation amounting to S/.917.49 for the case of the UDDT S/.1, 036.36 for dry latrine.

- The cost effectiveness index of cost of operating the UDDT gives a cost per person S/. 4.59 and dry latrine S/. 5.18 per person.
- One aspect to consider is that the total investment tends to decrease, in both cases, when greater numbers of households using the systems, due to the reduction of pre-investment costs, with consequent reduction in rate cost affects the effectiveness of the total investment

Other benefits of dry ecological toilet are reducing spending on health, reducing environmental pollution, the incorporation of healthy habits in the residents, the costs that are avoided in the environmental remediation and community participation in managing waste streams of gray water.

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AGUAECOSANPERU	Busienss of water and ecological sanitation in Peru
APGEP-SENREM	Program "environment, participation and private managment"
ASHOKA	Promotes social entrepreneurs and actions between them
AVINA	Promotes alliances between social leaders and entrepreneurs
CCI	International Conlsulting Committee
CENCA	Urban Development Institute CENCA
COVAP	Neighborhood drinking water committee
DIGESA	Environmental Health Department
ECODESS	Ecology and Development wiht Sustainable Sanitation
ECOSAN	Ecological Sanitation
EPS	Service provider company
FONDAM	Fund of the Americas
IGV	General Sales Tax
ITDG	Intermediate Technology Development Group - Practical Solutions
JASS	Board Administrator, Sanitation
MINSA	Ministry of Health
MVCS	Ministry of Housing, Construction, and Sanitation
NGO	Non-Governmental Organization
NMP	Most Probable Number
OMA	Office of the Environment
OPS	Panamerican Health Office
SEDAPAL	Potable Water and Sewage Lima
SSLP	Health without Borders Perú
TEA	Annual Effective Rate
TEM	Monthly Effective Rate
UDDT	Urine Diverting Dry Toilet
UNALM	National Agrarian University la Molina
UNDP	United Nations Development Program
WSP – BM	Water and Sanitation Program administered by the World Bank

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Architect, graduate of the National University of Engineering (UNI) and of Masters Studies in Planning and Environmental Urban Management; associate member of the Institute for Urban Development CENCA, his experience has been determined by the need to contribute a sustainable society and environment for the general population, implementing, through CENCA, urban, environmental, and advising of cities management projects with urban rivers (PGU-ALC/HABITAT/NNUU).

Since 1997, he has driven the pioneering work of Ecological Sanitation in Peru, venturing personal help from CENCA, along with ASHOKA, AVINA, and the Lemelson Foundation.

Carried by practice and support of the users of urine diverting dry toilets, he was recognized with the eco-efficiency award from the PCUP in 2002 and the second place international presentation award at the first Latin American meeting on Ecological Sanitation in Forteleza, Brazil in 2007.

He was a co-author of the experience "Innovative and sustainable proposals for the disposal, treatment, and reuse of solid waste and domestic liquids" 2002 and "Ecological Sanitation: Lessons learned in the suburban areas of Lima" 2006.

In the present publication, "A guide for an integrated system of ecological sanitation in suburban and rural areas, ECODESS," Calizaya invites the participation of professionals and institutions to analyze the use of the micro-system, describe its components, and apply its form.