Case study of sustainable sanitation projects

Ecosan demonstration pilot in two rural schools Apulo Municipality, Cundinamarca, Colombia

Fig. 1: Project location

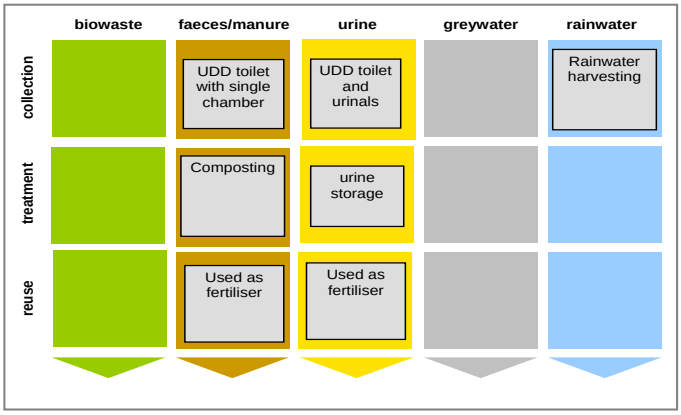


Fig. 2: Applied sanitation components in this project

1 General data

Type of project:
Ecological sanitation pilot in rural schools

Project period:
01/2011 – 04/2011: Planning process.
05/2011 – 06/2011: Capacity building.
07/2011: Installation of prefabricated ecological sanitation units in the rural schools of La Horqueta and Guacamayas.
07/2011 – 04/2012: Follow-up and monitoring of use and function of ecological sanitation unit in La Horqueta school and adjustments in the unit of Guacamayas school.
02/2012: Installation of improved dry sanitation unit in Guacamayas school.

Project scale:
22 pupils between 5 and 12 years
2 teachers
2 kitchen maids
Total: 26 persons directly benefited

Address of project location:
Colombia, Cundinamarca Department, Apulo municipality, La Horqueta and Guacamayas rural sectors, Rural schools (La Horqueta: N 04º27'00.0" - W 074º35'17.9", 415 masl; Guacamayas: N 04º33'25.2" - W 074º35'08.0", 470 masl).

Executing institution:
El Bosque University
Program: *Environmental Engineering*
Research Division: *Health and Environment Institute*
Research group: *Ecological Sanitation, Health and Environment*

2 Objective and motivation of the project

The general objective is to implement a pilot project of ecological sanitation in two schools located in the rural area of Apulo municipality, allowing the generation of knowledge about its use, maintenance and benefits, while serving as demonstration model for the two communities. At the same time, the technology is validated and evaluated in a scholar context in Colombia.

Specific objectives:

- Identifying manufacturers in Colombia involved in the production of ecological dry toilets and model adjustment for use by children.
- Selecting schools interested in participating in the project and installation of prefabricated ecological sanitation units.
- Providing follow-up and support to the community during eight months.
- Presenting proposals of design improvements of the two implemented sanitation models.

3 Location and conditions

Apulo municipality

This municipality is located in Cundinamarca department, 2.5 hours drive away from Bogotá. Apulo has an average temperature of 26°C and is situated 400 meter above sea level (Gobernación de Cundinamarca, 2011). (Fig.3).

Fig. 3: Location of the rural schools Guacamayas and La Horqueta in Apulo municipality, Cundinamarca departament, Colombia.

Ecosan demonstration pilot in two rural schools Apulo Municipality, Cundinamarca, Colombia

La Horqueta and Guacamayas are two of 14 schools located in the rural area of Apulo municipality. These two schools lack connections to water supply systems, and therefore depend on rainwater harvesting and tank trucks. At the project start up, the schools had waterborne sanitation units but without water connection and infiltration pits in precarious conditions. The water supply and the improved sanitation conditions in these two schools were insufficient to satisfy the basic needs for the school children and staff. (Fig. 4)

Fig. 4: La Horqueta school (a) and Guacamayas school (b) (Photos: Gutiérrez and Rodríguez 2011)

4 Project history

Background

The water and sanitation coverage gap between rural and urban areas is huge, especially in developing countries according to the Millennium Development Goal (MDG) reports, both at a global level (United Nations, 2012) and at national level in Colombia (PNUD, Colombia, 2011).

In Colombia, 63,5% of the population lack access to water of drinking water quality, according to the Water Quality Risk Index[1] (INS, 2012). The drinking water coverage in urban areas is 99% and 72% in rural areas, while the coverage for access to improved sanitation is 82% in urban areas and 63% in rural areas (OMS/OPS 2011).

Poor health and environmental conditions in which the rural population develop their lives are widespread phenomena in Colombia, hence the Health and Environment Institute of El Bosque University in Bogotá, has focused their work in this field. The schools located in rural areas of Apulo, Anapoima and La Mesa municipalities all represent this context. During the last seven years, the Institute works in projects of applied research and social responsibility in such schools in themes related to health and environment, which includes the promotion and implementation of alternatives systems of sanitation.

According to data from Inter American Development Bank, only 54% of public schools in rural areas in Colombia have access to drinking water, 57% to sewage system and only 40% to proper quantity of toilets per pupils (Duarte, Garglio y Moreno, 2011). This situation is clearly evidenced in Apulo municipality where communities take water from local water supply systems without treatment, rainwater or tank trucks. In addition, excreta is disposed in latrines connected to septic pits, in bad state or saturated, or practice open defecation (UEB, 2010).

This project was developed in two rural schools in the Apulo municipality. Both schools have similar infrastructure and number of persons. In each school a prefabricated unit with urine diverting dry toilet was installed, which have been manufactured by two national companies. Subsequent to the installation the sanitation units were followed-up and monitored. The acceptance within the academic community of the new technology was also evaluated, and improvements were proposed to the prefabricated models.

At the start of the project a literature review was carried out to examine existing ecological sanitation projects developed in schools in rural areas of Colombia. No similar studies were encountered. However, various studies from experiences developed in urban areas have been conducted in the country, but none in scholar context (Delgado, 2008)(Carrasco, 2011).

Methodology and research design

The methodology used to develop research was an inductive, qualitative and descriptive approach. The scholar community inception was carried out with the ethnographic method, i.e. developing interviews and surveys, taking into account activities, customs, thoughts and perceptions in relation to the themes of sanitation and excreta disposal.

The project was developed during March 2011 and April 2012 in Guacamayas and La Horqueta schools.

In the first phase, a review of literature on related topics was carried out and the identification of Colombian manufacturers developing UDDT technology. Once the potential UDDT models were identified, some changes were requested to the companies to facilitate their use by children. In an introductory meeting with teachers from the 14 rural schools of Apulo municipality, two schools were selected for participation in the project. The criteria of the selection were schools with similar sanitation situations that also lacked connection to a water supply system.

A second phase consisted of a dynamic training addressing the educative community and parents. Through workshops, themes related to ecological sanitation and dry toilets were introduced. Subsequently, the installation of prefabricated modules was carried out in the Guacamayas and La Horqueta schools. The importance of adequate use and maintenance of the new technology was stressed, in addition to a proper personal hygiene.

The third phase was the project follow-up. During eight months, following-up visits were carried out each 15 days, which also were complemented with follow-up phone calls for a constant support to the process. The gathered monitoring information was registered using a follow-up template and photographic register.

In the final phase, the gathered information was analyzed to ensure necessary adjustments to the two prefabricated models and to observe the reactions of the community in front of a new sanitation alternative.

5 Technologies applied

In this demonstration project, the urine diverting dry toilet technology was implemented. This technology consists of separate urine and fecal matter management, where the collection is done in a separate and safe manner.

The prefabricated models of ecological dry toilets implemented in the pilot project were produced by two different national manufacturers. Each model consists of a prefabricated sanitation unit, including male urinal, urine diverting dry toilet and storage tanks for the collection of urine

[1] In Spanish IRCA, Índice de Riesgo de la Calidad del Agua.

and fecal matter. The main difference between the two models is the level in which they are installed; one has the entrance on the floor level (Fig. 6) and the other 1 m above floor level (Fig.5). This has implications on the volume and location of the storage tanks. The models arrived to school ready to be assembled. The only structure that had to be constructed on site was the concrete slab on which the models were placed.

Fig. 5: Prefabricated UDDT unit, La Horqueta school, Model 1. (Photo: Gutiérrez and Rodríguez 2011)

Fig. 6 Prefabricated UDDT unit, Guacamayas school, Model 2. (Photo: Gutiérrez and Rodríguez 2011)

6 Design information

The first prefabricated sanitation unit (Fig. 5 and 7) was installed in La Horqueta school. It measures 2,66 m (height), 1 m (length) and 1 m (width), and contains the urinal and the urine diverting dry toilet. In the external part and below the unit the 38 l urine storage tank and 80 l fecal matter storage tank were located. In addition, there is a gutter for rain water harvesting which feed a 38 l tank that also is located in the external part of the unit.

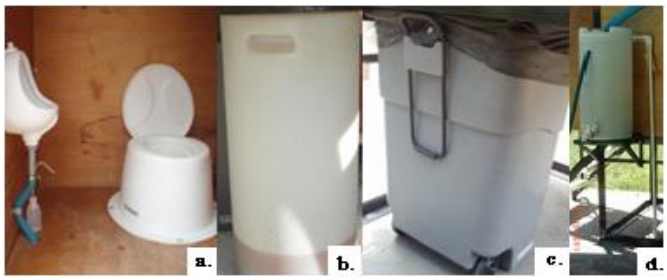


Fig. 7: Model 1: a) urinal and UDDT seat; b) urine collection tank; c) fecal matter collection tank; and d) rainwater harvesting tank (Photos: Gutiérrez and Rodríguez 2011)

The second prefabricated sanitation unit (Fig 6 and 8) installed in Guacamayas school, consists of a cabin with 2,1 m height, 2,1 m length and 1,5 m width. The storage tanks for urine is 6 liters and fecal matter 20 l, which both are located inside the unit. In the external part there is a 6-liter tank to collect the urine coming from the urinal.

Fig. 8: Model 2: a) urine and fecal matter collection tank; UDDT seat; b) urine collection tank; c); and d) urinal (Photos: Gutiérrez and Rodríguez 2011

7 Type and level of reuse

The urine diverting toilet and urinals, direct the urine to a collection tank. When the tank is full, the urine is conducted to a second tank in which the urine is stored during two months to increase the pH, which allow for the elimination of pathogens. During the storage time the color of urine changes and the characteristic odor of urine decreases. After storage, the urine is applied as a liquid fertilizer (Fig. 9).

Fig. 9: Urine handling and application as fertilizer in school garden. La Horqueta school. (Photos: Gutiérrez and Rodríguez 2012)

The fecal matter is composted and stored during several months. After that, treated fecal matter can be used in agriculture to reincorporate nutrients to the soil, while protecting the health, saving water and avoiding contamination of water bodies. The composting tank for fecal matter is located away from the dry toilet module. The composting tank has ventilation protected with a net to allow an aerobic composting. The tank is also black that helps to maintain high temperatures. A mixture of ash and sawdust is used as drying material. The ashes are brought to school by the pupils whose families cook with firewood. Once the composting tank is full, the mixture of drying material, fecal matter and toilet paper is stored for six months to allow the decomposition and stabilization of the material. With this process, the mixture becomes a bio-solid which later is used to cultivate ornamental plants in the two schools (Fig. 10).

Fig. 10: Treatment and final productive disposal of treated fecal matter. La Horqueta school. (Photos: Gutiérrez and Rodríguez 2012)

As a complementary activity to the project, the school vegetable garden was reactivated together with the pupils of La Horqueta school. The cultivation area was divided in two equal parts, each with two different plants, namely coriander and beans. The goal of the division was to make field trials with and without the application of urine as a fertilizer, and observe the result in the growth of the plants (Fig 11).

Fig. 11: Reactivation of school cultivation garden. La Horqueta school (Photos: Gutiérrez and Rodríguez 2012)

8 Further project components

Educational process

The educational process was carried out through introductory workshops on themes covering sanitation, ecosan, urine diverting systems, importance of adequate use and maintenance of this new technology, and its link to health protection and water saving.

The training material included working guidelines, pictures and other tools, e.g. marionettes, as presented below:

- *Workshop 1 - Introduction to sanitation, ecosan and urine diverting dry toilets* (Fig. 12)

Activities developed through workshop guideline 1:

- ✓ Presentation dynamics and group relaxation
- ✓ Introduction to sanitation and associated problems
- ✓ Knowledge feedback

Fig. 12: Workshop 1 – Guacamayas school (Photos: Gutiérrez and Rodríguez 2012)

- *Workshop 2 – Use of cleaning material for the sanitation unit* (Fig. 13)

The cleaning material for the sanitation unit and for personal hygiene was given to the schools:

- ✓ Toilet paper
- ✓ Liquid soap for hands
- ✓ 1 washing sponge
- ✓ 1 package of hand towels
- ✓ Liquid detergent for cleaning of sanitation unit

Fig. 13: Workshop 2 – La Horqueta school (Photos: Gutiérrez and Rodríguez 2012)

- *Workshop 3 – Sanitation and ecosan training for parents of the pupils*

Initially, with support from working guide 2 the themes of sanitation and ecosan were explained again to the pupils but now with the participation of their parents. The importance of the project and its benefits were demonstrated.

The sanitation units were inaugurated and taken into use. To facilitate the adequate function a poster describing how the toilet should be used is placed within the unit (Fig. 14).

Fig. 14: Poster describing adequate use of UDDTs. The pictures are adapted from: http://www.rotaria.net/peru3/rotaria/files/DL_7_Man.jpg

Project follow-up

A comprehensive project follow-up was set to a period of 8 months, in which field visits were carried out every second week, complemented with phone calls every week. The visits were registered using a follow-up format. The follow-up included a survey to gather the perception on the use of the sanitation unit and an observation checklist to support the verification of use, maintenance, and the state of the construction, and volume of the collected urine and faeces. In the follow-up phone calls with school teachers questions on perceptions and usage were also included. These questions made it possible to detect failures in the sanitation units, which are presented in section 10. The necessary adjustments were made in the subsequent visits.

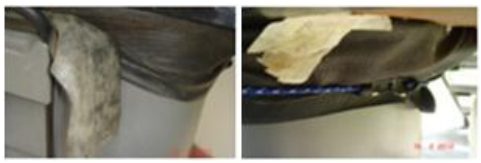
Implemented adjustment in the sanitation models

In the following section all the adjustments made two the original designs are presented.

- *La Horqueta school – Model 1*

The support from the manufacturer responsible for model 1 was constant, which was important to adapt it to the needs of the site and the context.

Table 1: Implemented adjustments in the sanitation unit in La Horqueta school (model 1)

Sanitation component	Adjustments and photos (before and after)
Entrance of urine pipes in the jerry can	The urine pipes were joint to avoid stagnating urine, turbulence and generation of odors; an adaptation that also facilitated the removal of the jerry can. 
Change of position and color of the ventilation pipe	The ventilation pipe was extended to reach above the roof and was painted black to improve its function and avoid odors. 
Blocking the entrances of the storage tank (250 L) for fecal matter	The tank had openings that permitted the entrance of vectors. These were sealed and only small holes were left to enable air passage. A perforated pipe was installed inside the tank for improved ventilation and decomposition of fecal matter. 
Overflow and tap on rainwater tank	The valve on the rainwater tank was changed to a tap and an overflow pipe was installed in the upper part of the tank. 
Adjustment of the entrance door	The door post was modified, since the original design left an opening and did not offer full privacy for the users. 
Sealing of the storage tank of fecal matter	To improve the sealing of the collection tank for faeces, a new strap was used that goes all around the tank and is easier to handle. 

- *Guacamayas school – Model 2*

The sanitation unit installed in the school of Guacamayas presented severe faults in the design and the material. Consequently the usage was delayed by 6 months to allow for necessary adjustments. The main issues were the toilet seat and the combined toilet bench and chamber. A new seat had to be imported from Peru.

Table 2: Implemented adjustments in the sanitation unit in Guacamayas school (model 2).

Sanitation component	Adjustments and photos (before and after)
Toilet bench / chamber and seat	The original bench did not have a resistant surface and there was cracks and breaches in the corners, which did not generate confidence to use it. The size of the toilet seat was too large and the division wall for urine bowl was too high with sharp edges, which both generated inconveniences for the children. A new bench was constructed in wood and an appropriate seat was imported from Peru. 
Urinal	During the initial tests leakage was observed in the joints of the different parts of the urinal and the urine pipe. The levels of the urinal did not enable an adequate urine collection. The urinal was changed to a model without separate parts and was elevated allow for an adequate pipe angle. The urine pipe was also replaced. 

9 Costs and economics

The project was financially supported by the El Bosque University through an internal call for research projects in 2011. The total project cost was 6 million COP (approx. 2.328 EUR), of which 3,5 million was invested in the sanitary units. The remaining funds were used for travel and accommodation expenses, educational material, and cleaning material. The project did not contract any additional staff.

10 Operation and maintenance

Cleaning and maintenance of the sanitation units and also the management of collected excreta are carried out by the pupil, teachers and kitchen maids of the two schools. The register of excreta volume was used as an indicator for usage. Below the management of urine and fecal matter is described.

Urine management

The register of urine volumen generated in La Horqueta school showed the following result (Fig. 15). Training on how to reuse urine was carried out. After adequate storage, the treated urine was applied in shallow trenches around trees and in other plants in the schools.

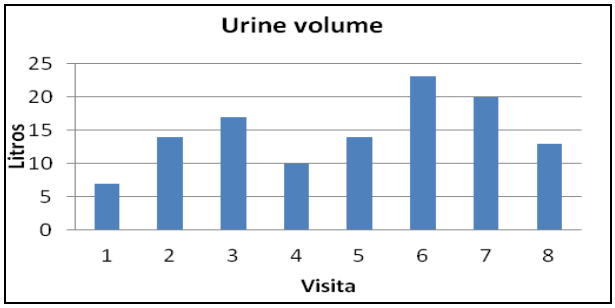


Fig. 15: Urine volume collection – La Horqueta school (Source: Gutierrez and Rodriguez 2012)

Management of fecal matter

The fecal matter weight registered in La Horqueta school is presented in Figure 16. This weight includes the faeces, dry material (ash and sawdust) and toilet paper.

The register of fecal matter showed that the use of the unit in the Horqueta school had been constant; an indication that the system had been accepted. At the beginning there were complaints about bad smell inside of the unit, which were explained with insufficient application of dry matter after defecation. Follow-up in the capacity building was conducted to improve this situation.

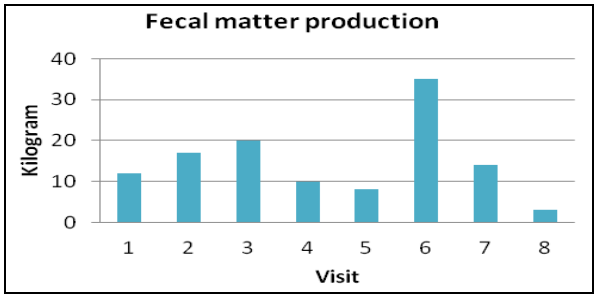


Fig. 16: Fecal matter collection – La Horqueta school. (Source: Gutiérrez and Rodríguez 2012)

An interesting note regarding the use is in times of school holidays during December and January. Even though there are no children in school the inhabitants in the village kept using the sanitation unit; the peak at the sixth visit corresponds to this period.

To ensure a proper treatment of the faeces, the collected material was transferred to a maturation tank. The material is left for storage during a period of six months. After storage the material is converted into a soil without odours, which was used in the plantation of ornamental plants (Fig. 16).

11 Practical experience and lessons learnt

La Horqueta and Guacamayas schools had sanitary units in deficient condition with presence of bad odors and with generally unpleasant status. Since no sewerage was available the generated wastewater was discharged into a damaged or saturated septic tanks, causing contamination to the environment and threatening the health of children and locals.

The academic community in La Horqueta school always showed interest in collaborating, this was demonstrated by the adoption of this new technology. Furthermore, it was evidenced that the constant support allowed the detection of faults occurring in the system on time and managed to keep the community motivated to continue using the toilet.

Although the teacher, the kitchen maid and the pupils of La Horqueta school are all involved in the operation of the module, children assimilated better and much easier this new technology compared to the adults. Despite their support to the project, the teacher and the caretaker only used the toilet once as they felt uncomfortable and not yet accepted to use a toilet with a non-conventional technology.

The sanitation module installed in Guacamayas school presented problems and drawbacks in the design from the outset. Hence the use of the module was postponed until the necessary adjustments were made. From the last capacity building activity until final delivery of the module almost a year passed by, this can explain why the project and the proposed new technology lost credibility for the teacher, kitchen maid and pupils. Once the adjustment had been implemented and the unit was ready to be used, the information shared in the initial workshops was no longer remembered and the basic training had to be done all over again to ensure the proper use and operation of the system.

The rainwater harvesting system in La Horqueta school proved to be efficient; the collected water is used for hand washing, the cleaning of the module, and for watering the school garden.

The handling of storage tanks of both urine and faeces turned out to be easy after the necessary adjustments were done. The changing and transferring of containers to the site of storage proved to be an activity that pupils can carry out without any problem.

Finally, the key lessons gained in this alternative sanitation project in rural schools are summarized:

- To talk about urine or faeces and the handling of excreta has always been a taboo, nevertheless through the development of the project it was demonstrated that through pedagogic activities, workshops, talks and accompaniment it is possible to overcome this taboo and children naturally take on the related topics.
- The results allow us to recommend this system in rural areas of the country since there are no limitations in the disposal of treated faeces and urine, which can advantageously be used in garden and cultivations, proving to be an efficient technology in the environmental conditions of the area.
- When introducing a new technology such as dry toilets, it is indispensable with involvement of all actors in the different phases of the project, so they do not feel forced or excluded but instead the activities are developed naturally generating an ownership over the system.
- The technology proves to be a system that functions in schools, especially since the cleaning and maintenance work can be carried out by the pupils, in this case children between 5 and 12 years. The children also demonstrated that there is no gender discrimination for the corresponding tasks and responsibilities.
- The technology is water saving since at no time of use or cleaning large amounts of water are needed, as a result, the water supplied to the la Horqueta school is now sufficient to cover the different demands.
- To develop dry sanitation projects that will require the change of attitude towards the use of faeces and urine it is recommended that from the start involve the children since they have the ability to accept and understand new alternatives through their open minds and ability to acquire knowledge.
- In Colombia the industry that are developing and commercializing these technologies are still on an initial stage and a continuous process of improvements are taking place.
- Despite the technical shortcomings presented in one of the sanitation units, at the end of the project it was evidently demonstrated that the two implemented sanitation systems were well functioning achieving the objectives proposed by the project.

12 Sustainability assessment and long-term impacts

A basic assessment (Table 1) was carried out to indicate in which of the five sustainability criteria for sanitation (according to the SuSanA Vision Document 1) this project has its strengths and which aspects were not emphasised (weaknesses).

Table 3 – 4 : Qualitative indication of sustainability of system. A cross in the respective column shows assessment of the relative sustainability of project (+ means: strong point of project; o means: average strength for this aspect and – means: no emphasis on this aspect for this project).

Model 1 – Horqueta school	collection and transport			treatment			transport and reuse		
Sustainability criteria:	+	o	-	+	o	-	+	o	-
• health and hygiene		X			X			X	
• environmental and natural resources	X			X			X		
• technology and operation	X				X			X	
• finance and economics	X					X			X
• socio-cultural and institutional	X				X			X	

Model 2 – Guacamayas school	collection and transport			treatment			transport and reuse		
Sustainability criteria:	+	o	-	+	o	-	+	o	-
• health and hygiene		X			X			X	
• environmental and natural resources	X			X			X		
• technology and operation			X		X			X	
• finance and economics		X				X			X
• socio-cultural and institutional		X			X			X	

Sustainability criteria for sanitation:

Health and hygiene include the risk of exposure to pathogens and hazardous substances and improvement of livelihood achieved by the application of a certain sanitation system.

Environment and natural resources involve the resources needed in the project as well as the degree of recycling and reuse practiced and the effects of these.

Technology and operation relate to the functionality and ease of constructing, operating and monitoring the entire system as well as its robustness and adaptability to existing systems.

Financial and economic issues include the capacity of households and communities to cover the costs for sanitation as well as the benefit, such as from fertiliser and the external impact on the economy.

Socio-cultural and institutional aspects refer to the socio-cultural acceptance and appropriateness of the system, perceptions, gender issues and compliance with legal and institutional frameworks.

For details on these criteria, please see www.susana.org: the SuSanA Vision document "Towards more sustainable solutions"

Regarding the long-term impacts; the main expected outcome of the project is the generation of acceptance and ownership of a new sanitation technology for rural communities. This project highlights the role of schools as demonstration center for the community in rural areas. As a result of this project, together with the interest of the community and various organizations, these sanitation systems are currently being replicated in rural households in the area.

13 Available documents and references

Calvert, P., Morgan, P., Rosemarin, A., Sawyer, R., & Jun, X. Ecological Sanitation. Stockholm Environment Institute. 2004.

Carrasco, M. W. Tecnologías alternativas en agua, saneamiento e higiene en situaciones de emergencias y desastres. Ficha tecnica de unidad sanitaria seca con separación de orina. Bogotá. (2011).

Delgado, R. C. Cuadernos de Vivienda y Urbanismo. Universidad Javeriana. Bogotá D.C. (Febrero de 2008). Recovered on April 4 of 2012, from: http://www.javeriana.edu.co/viviendayurbanismo/pdfs/11CnosViv-2.pdf

Duarte, J., Gargiulo, C. & Moreno, M. Infraestructura Escolar y Aprendizajes en la Educación Básica Latinoamericana: Un análisis a partir del SERCE. Banco Interamericano de Desarrollo, BID. (2011). Retrieved from: www.iadb.org/en/publications/publication-detail,7101.html?id=20667%20&dcLanguage=en&dcType=All

Esrey, S. A. Cerrando el ciclo - Saneamiento ecológico para la seguridad alimentaria. México: Sarar Transformación, SC Tepoztlan, México. (2001).

Gobernación de Cundinamarca. (2011). Municipio de Apulo. Recovered on October 23 of 2011, from: www.apulo-cundinamarca.gov.co

Instituto de Salud y Ambiente, Universidad El Bosque. Diagnostico ambiental de las escuelas rurales de Anapoima y Apulo. (2010).

Instituto Nacional de Salud (INS). Estado de la vigilancia de la calidad de agua para consumo humano. SIVICAP. (2012)

Kvarnström, E., Emilsson, K., Stintzing, R., Johansson, M., Jönsson, H., Petersens, E., y otros. Desviación de Orina: Una paso hacia el Saneamiento Sustentable. EcoSanRes. (2006). Retrieved from: http://www.ecosanres.org/pdf_files/Desviacion_Orina_2006-1.pdf

Molinar, Y., Guerrero, H. M., Tamised, F. J., & Zuñiga, R. Diseño y construcción de sanitarios ecológicos en áreas rurales. (2006). Retrieved from: http://bvs.sld.cu

Morgan, P. Compost making toilets. Toilets that make compost. Estocolmo: Practical Action Publishing. (2008).

Naciones Unidas. Objetivos de Desarrollo del Milenio. Programa de las Naciones Unidas para el Desarrollo, PNUD. (Junio de 2012). Retrieved on March 13 of 2013, from: http://www.undp.org/content/dam/undp/library/MDG/spanish/MDG%20Report%202012%20-%20Complete%20Spanish.pdf

Organización Mundial para la Salud, OMS., Organización Panamericana de la Salud, OPS. Situación de las Américas. Indicadores Básicos. (2012)

Programa de las Naciones Unidas para el Desarrollo, PNUD, Colombia. Objetivos de desarrollo del milenio, podemos lograrlos. (2011). Retrieved on February 27 of 2011, from: http://odm.pnudcolombia.org/index.php?option=com_content&viewcategori&lightout=lock&id=6&itmid=15

Sawyer,R., Friedman, B. & Delmaire,A. Sarar Transformation. (2003). Recovered from: http://www.sarar-t.org

Schonning, C., Stenstrom, T. A. Lineamientos para el uso seguro de la orina y las heces en sistemas de saneamiento ecológico. EcoSanRes. 2004. Retrieved from: http://www.ecosanres.org/pdf_files/Uso_Orina_Heces_Ecosan_2004-1.pdf

World Health Organization, WHO.Guidelines for the safe use of wastewater an excreta in agriculture and aquaculture. Switzerland: Geneva. (1989).

World water week. Matiz, M. I. Environmental of the rural schools and the relation to pupil´s health in a municipality from Colombia. Estocolmo, Suecia: Alfa Print. (2007).

14 Institutions, organisations and contact persons

For more information about the sanitation models, please contact:

Health and Environment Institute, El Bosque University, Bogotá, Colombia

E-mail: saludambiente@unbosque.edu.co

Case study of SuSanA projects

Demonstration pilot of Eco-sanitation in two rural schools SuSanA 2013

Authors: María Inés Matiz Salazar (El Bosque University. Bogota, matizmaria@unbosque.edu.co); Juan Felipe Jaramillo Gómez (El Bosque University. Bogotá, jjaramillo@unbosque.edu.co); Carlos Alberto Gutiérrez Gutiérrez (El Bosque University, Bogotá, cagutierrezg7@hotmail.com); Natalia Catherine Rodríguez López (El Bosque University, Bogotá, natisrodri_06@hotmail.com); Kim Andersson (SEI, kim.andersson@sei-international.org).

Editing and reviewing: Kim Andersson (SEI, kim.andersson@sei-international.org), Patricia Villarrubia Gómez (SEI-intern, pattyvg1@hotmail.com])