sustainable sanitation alliance

Case study of sustainable sanitation projects

UDD toilets with reuse in allotment gardens Cagayan de Oro, Philippines

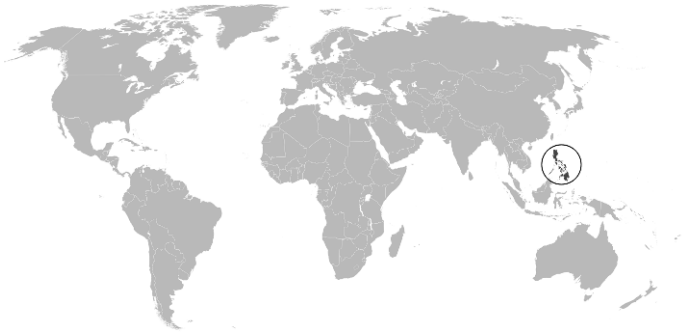

Fig. 1: Project location

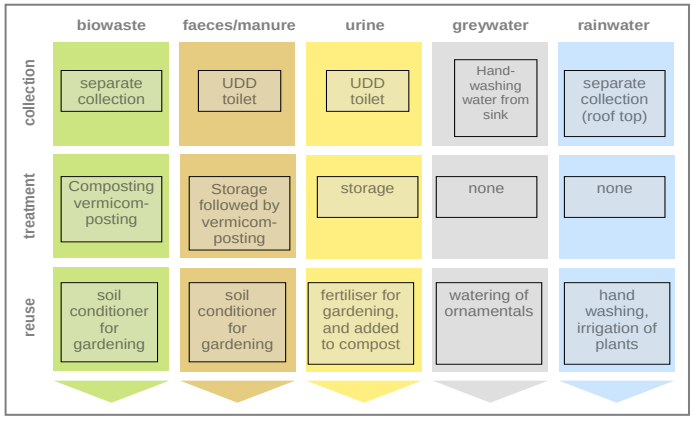

Fig. 2: Applied sanitation components in this project

1 General data

Type of project:

Urban upgrading (large pilot-scale)

Project period:

Start of planning: May 2005
Start of construction: October 2005
Start of operation: November 2005
Ongoing monitoring: planned until 2009

Project scale:

100 urban poor families in 10 self-sustaining allotment gardens (3 within premises of public elementary schools) in 8 city districts (barangays). Nine allotment garden have one UDD toilet each.

Address of project location:

Barangays Balubal, Balulang, Carmen, FS Catanico, Gusa, Kauswagan, Lapasan and Macasandig
9000 Cagayan de Oro City
Philippines

Planning institution:

Periurban Vegetable Project (PUVeP)
Xavier University – Research & Social Outreach (RSO)
Manresa Farm
9000 Cagayan de Oro City
Philippines

Executing institution:

Same as planning institution

Supporting agency:

Local government units of Balubal, Balulang, Carmen, FS Catanico, Gusa, Kauswagan, Lapasan and Macasandig Kauswagan, Carmen and Gusa (all Cagayan de Oro)

City Government of Cagayan de Oro (Philippines)
German Embassy, Manila, Philippines
Center for International Migration (CIM), Frankfurt/M., Germany

2 Objectives and motivation of the project

The overall objective of the project is to improve the living conditions for urban poor families of Cagayan de Oro City through the introduction of the ecological sanitation concept in several allotment gardens of the city.

The specific objectives are in line with PUVeP's mandate as a research and social outreach unit of Xavier University, namely:

- developing economically viable, environmental benign and socially accepted community-based vegetable production systems to ensure the supply of affordable, healthy vegetables, particularly to the urban poor;
- promoting ecological sanitation systems to close the loop in the nutrient cycle which cities have broken;
- integration of urban and periurban food production and ecological sanitation systems into city planning by using participatory, asset-based approaches;
- integration of urban and periurban agriculture and ecological sanitation in relevant academic curricula, research and social outreach programs of Xavier University.

3 Location and conditions

Cagayan de Oro City is located in the province of Misamis Oriental on the Northern coast of Mindanao, the most Southern island of the Philippine archipelago. It is a rapidly growing urban centre with more than 600,000 inhabitants.

Fig. 3: Demonstration allotment garden with UDD toilet at Manresa Farm, Cagayan de Oro City (source: PUVeP 2008).

UDD toilets with reuse in allotment gardens Cagayan de Oro, Philippines

The city is subdivided into 80 city districts (*barangays*). The allotment gardens have been set up in the barangays of Balubal, Balulang, Carmen, FS Catanico, Gusa, Kauswagan, Lapasan and Macasandig. In addition, one allotment garden demonstration and training area with UDD toilets, vermicomposting and biogas facilities was established in Manresa Farm, which forms part of the Xavier University campus. It serves as training venue for students, farmers, staff of government and non-government agencies, as well as a showcase for the general public. The size of the gardens varies depending on the number of participating families (between 7 and 23 families) with an average area of 300 m^2 per family, plus the necessary space for commonly used areas such as composting, nursery, UDDT, tool shed and the like.

Fig. 4: Double vault UDDT in barangay FS Catanico (source: PUVeP 2008).

The project was implemented to address some socio-economic and environmental challenges caused by the rapid growth of Cagayan de Oro which is representative for the Philippines being classified among the world's fastest urbanizing countries. Among the major challenges that urban areas in the country are facing are:

- Availability, accessibility and affordability to safe and nutritious food for its residents, otherwise known as food security. The poorest sector of the Philippines, which comprises almost 40% of all households, spends about 60% of its income on food.
- 20% of Filipinos are regularly suffering from hunger and about one third of all children are underweight with iron deficiency anaemia and low vitamin A levels.
- Average per capita vegetable consumption is very low with 36 kg per year.
- Further, two thirds of all children suffer from intestinal worms due to lack of water and appropriate sanitation facilities at home and in schools.
- More than 90% of the wastewater is untreated and pollutes the water bodies.

4 Project history

The Periurban Vegetable Project (PUVeP) is a research and social outreach unit of Xavier University, located in Cagayan de Oro City, Philippines. It started its operation in October 1997 under the College of Agriculture and transferred to the newly established Research and Social Outreach Cluster (RSO) on July 1, 2008.

In 2003, the first allotment garden was established as part of a European Union funded project following a period of agronomic and socioeconomic researches in cooperation with German, Belgian and Philippine universities, local government units and non-governmental organizations. As of 2008, this number has grown to ten self-sustaining gardens located in different urban and periruban areas of the city, three of them within the premises of public elementary schools enabling more than 100 urban poor families the legal access to land for food production. Aside from different vegetables, some gardeners grow also herbs and fruits. In some gardens, small animals are kept to provide an additional income source. Each allotment garden has a compost heap where biodegradable wastes from the garden as well as from the neighboring households are converted into organic fertilizer, thus contributing to the integrated solid waste management program of the city.

Shortly after the first community-based allotment gardens were established, one of the constraints observed was the lack of sanitary toilet facilities inside the gardens. A sustainable solution to address this sanitation problem had to be found.

Several stakeholder meetings with community members and local government officials took place. The model of a urine-diversion dehydration (UDD) toilet, similar to those used in Danish allotment gardens (Bregnhoj, 2003), was introduced and discussed as one of the possible alternatives. This idea was introduced to Cagayan de Oro after one of the PUVeP technicians attended a training course on ecological sanitation at the Stockholm Environment Institute (SEI) in 2004. Research conducted by PUVeP as part of the SEI course requirements showed that the application of urine increased the marketable yield of sweet corn by an average of 14%.

Similar experiments were also carried out for non-food crops in cooperation with commercial growers in different areas of Cagayan de Oro. The urine application resulted in earlier and increased flowering of different ornamental plants with subsequent better marketability, as confirmed by the growers. Greenerleaves and healthier crop stand in general were reported for certain palms and mango seedlings, which are traits appreciated by both growers and customers.

Socioeconomic studies were also conducted to investigate urban growers' and customers' acceptance of crops fertilised with treated urine and faeces. Initial studies showed that acceptance among allotment gardeners was high, with an approval rate of more than 90%, since for them treated urine and faeces were not much different from the animal manure commonly used. However, only about 60% of the potential customers said that they were willing to buy vegetables fertilised with human urine and faeces, indicating the need for a strong information and education campaign to increase acceptance of vegetables produced in such a way.

Further developments based on the allotment garden UDDT experiences:

As a result of different capacity building activities of PUVeP, more than 30 UDDTs were established by several non-government agencies in other areas of the province of Misamis Oriental (see separate SuSanA case study), as well as in the provinces of Lanao del Norte and Zamboanga. Most of them are located in public schools which do not have proper sanitation due to lack of water. When toilets are dirty and non-functional, open defecation is the only option left leading to serious hygienic concerns. Provision of hand washing facilities

and tooth-brushing troughs by another project further complements the basic hygiene concept of these pilot schools.

Additonal 15 UDDT were established by PUVeP in rural communities of Northern Bukidnon, particularly in the municipality of Manolo Fortich and in the neighboring barangay of Balubal, Cagayan de Oro City. Primary and high schools as well as a chapel are among the beneficiaries.

5 Technologies applied

Double-vault urine-diversion dehydration toilets (UDDTs) are used for the collection of faeces and urine. Once the first vault is full (after approximately one year), the second vault is used by transfering the UDD bowl. A 1:1 mix of sawdust and lime is used as covering material for the faeces. Sawdust is easily available in Cagayan de Oro and free of charge. However, it has to be filled into bags and hauled at own cost. Lime is available at 12 to 15 PhP per 50 kg-bag (€ 0.24 – 0.3) and is used to raise the pH of the faeces to increase pathogen destruction. In case lime and/or sawdust are not available, ash, rice hulls and dried soil are recommended to be used as substitutes since those are usually available free of charge.

Fig. 5: The cemeted hole on the floor (left) is for anal washing, the blue container in the back (left) contains a mix of sawdust and lime (1:1) used as cover material for the faeces; the green container is for the collection of used toilet paper (source: Wafler, 2008).

The **waterless urinal** for men is a modified plastic container used normally for drinking water since those are very cheap compared to ceramic urinals. One side of the container is cut in a “U” shape and it is connected with a pipe at the bottom. A rubber balloon which is placed at the end of the pipe at the opening of the storage container (see Fig. 9) expands when it is filled with urine and allows urine to flow into the container. Once emptied, the rubber balloon contracts and, thus, seals the container and prevents odor emission.

Rainwater is collected from the roof top of a neighbouring building and stored in a cistern. A piping systems leads to the allotment garden and UDDT, and is used for handwashing and irrigation. Greywater from the handwashing is reused for irrigation of ornamentals.

Fig. 6: Ceramic urine-diversion toilet pedestal, inside of the toilet house shown in previous photo (source: DILG-GTZ Program; see also supplier’s website: www.ecosan.ph).

Fig. 7: The recycled water container serves as waterless urinal for men while the sink next to it is for hand-washing. Below the sink is a bucket that contains collected rainwater for handwashing with soap (Source: PUVeP, 2008).

Fig. 8: Sawdust-lime mixture as covering material (source: Wafler, 2008).

Fig. 9: A rubber balloon which seals once the urine enters the container, prevents odour emission through the pipe (source: PUVeP, 2008).

Fig. 10: Collected urine is stored in a plastic jerrican. The filled container is then sealed and placed in full sunlight for a period of one month for further pathogen destruction (source: PUVeP, 2008).

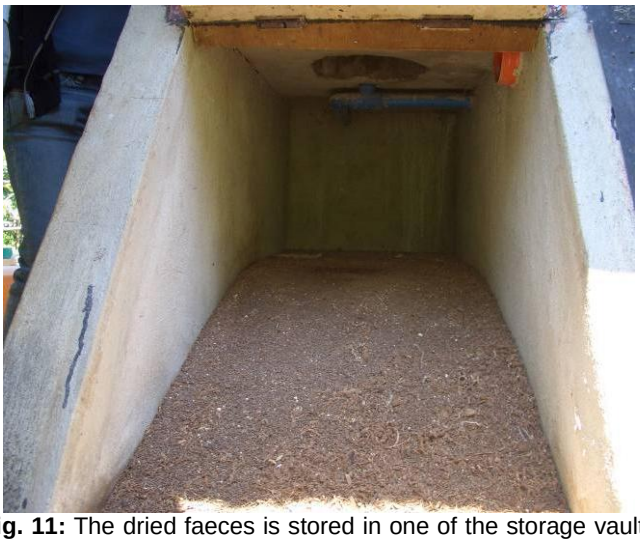

Fig. 11: The dried faeces is stored in one of the storage vaults for a period of one year after the last defecation has occurred (source: Wafler, 2008).

Fig. 12: Robert Holmer on the right with handful of dried faeces: **"***To believe is: …not to smell*" (source: PUVeP, 2008).

Fig. 13: Dried faeces after several months of storage (source: PUVeP, 2009).

6 Design information

The design of the double-vault UDD toilets of Cagayan de Oro was adapted from an ecosan project of Barangay Tingnan, Panglao Island, Bohol, Philippines of the DILG-GTZ Water and Sanitation Program (see Fig. 14). See also the separate SuSanA case study on this project.

UDD toilets with reuse in allotment gardens Cagayan de Oro, Philippines

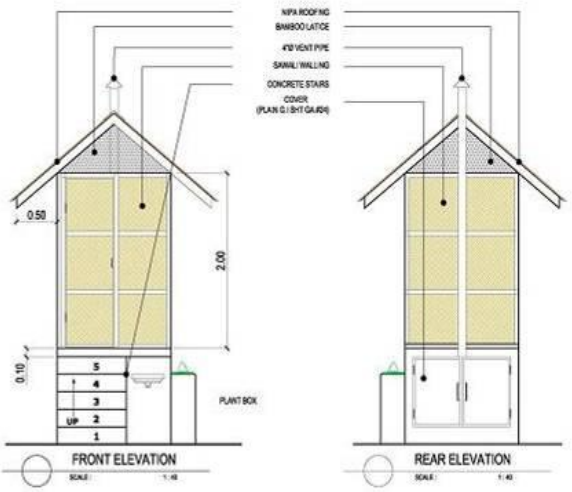

Fig. 14-a: Design drawings for double-vault UDD toilets (source: DILG-GTZ Water & Sanitation Program Philippines, 2005).

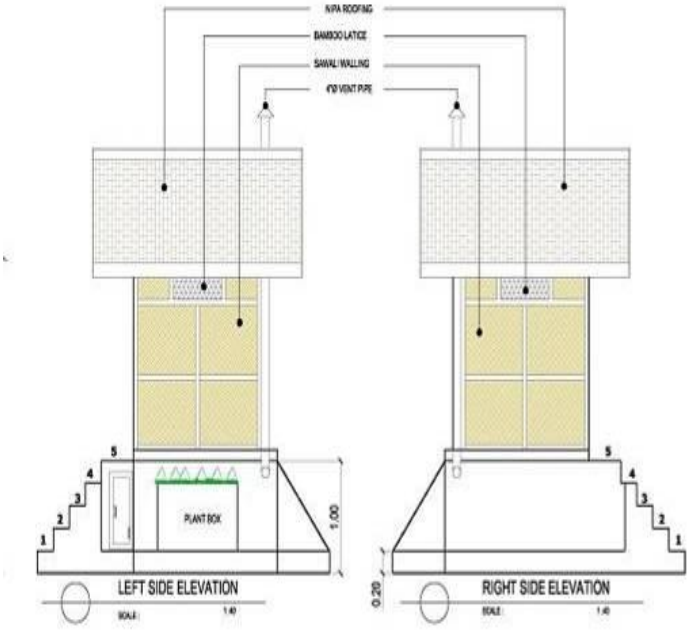

Fig. 14-b: Design drawings for double-vault UDD toilets (source: DILG-GTZ Water & Sanitation Program Philippines, 2005).

Design data:

- Floor area: 2 m x 1.5 m
- Floor Elevation: 0.9 m
- Ventilation pipe: diameter 2 inch, PVC
- Ceramic UD waterless bowl for urine and faeces separation
- 20 l plastic container for collection and storage of urine
- Nipa (coarse weaved palm leaves) for the roofing
- Plain G.I. Ridge roll
- For the faeces vault door plain G.I. is used painted black to increase the absorption of heat from the sunlight.
- 4x4 coconut wood for the posts in 4 corners of the toilets.
- For the urinal pipe 1" diameter also for the urinal drain difference.

Fig. 15-a: User guidelines "Do's" for UDD toilets (source: DILG-GTZ Water & Sanitation Program Philippines, 2006).

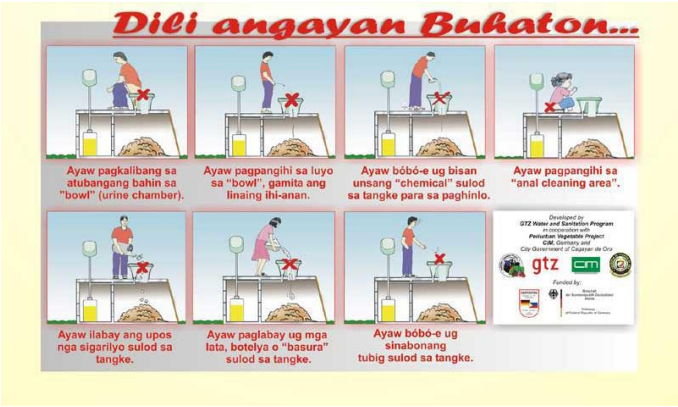

Fig. 15-b: User guidelines "Don'ts" for UDD toilets (source: DILG-GTZ Water & Sanitation Program Philippines, 2006).

7 Type of reuse

Urine is mainly used as a side-dress fertilizer after diluting it with water before application to plants (1 part urine to 3-5 parts of water depending on age of plant). Plants at seedling stage are more sensitive, hence a higher dilution (e.g. 1:5) is recommended compared to more mature plants. The following guidelines are given for the reuse of the treated urine:

- After the last urination, remove container from UDD toilet and store urine undiluted and in a closed container for 1 month to eliminate all pathogens.
- Storage in a sealed container prevents contact with humans or animals and hinders evaporation of ammonia
- During storage, the urine should not be diluted to provide a harsher environment for micro-organisms.
- Prior to application to crops dilute at a rate of 1 part urine with 3-5 parts of water.
- Urine can be considered as a liquid fertilizer since nutrients in urine are mostly water soluble, hence, are directly available for plant uptake.
- Urine should not be sprayed on plants but incorporated into the soil 10 cm away from the plant. This will reduce odor, foliar burns and the loss of nitrogen.

- Urine may also be applied through drip irrigation systems. However, clogging of emitters by salt precipitation may occur.
- Observe a waiting period of one month from last urine application to harvest of crops.
- Urine should not be applied to crops that are consumed raw (cucumber, lettuce, etc.) to ensure acceptance by costumers.

Fig. 16: Stored urine is harvested from jerrican (source: Wafler, 2008)

Fig. 17: Diluted urine ready for application (source: Wafler, 2008)

Fig. 18: Urine is applied about 5 to 10 cm from plant base (source: Wafler, 2008)

Fig. 19: After application, urine is covered with topsoil (source: Wafler, 2008)

Fig. 20: Urine is also used as a compost accelator. It is added to a compost pile when a lot of carbon-rich materials are used to reduce the C:N ratio (source: PUVeP, 2008).

Research studies conducted by Xavier University indicate that six months of storage may not fully eradicate the presence of helminth ova. Hence, for safe reuse of faeces, secondary treatment after storage is a must to prevent spreading of pathogens. The following procedures are recommended:

- Faeces should be kept in the storage vault of the UDD toilet for 6-12 months after the last defecation. Thereafter it should be subjected to a secondary treatment:
  - 60 days of vermicomposting

- aerobic composting where a temperature of > 50°C should be obtained during at least one week in the compost heap.

- After secondary treatment, the dried and composted faeces can be used like any other organic fertilizer where nutrients are slowly released as faeces-compost is degraded in the soil by soil organisms.
- To ensure acceptance of the produced vegetables by customers and to minimize health risks, it is recommended to use treated faeces not for vegetables but for fruit trees (banana, papaya, etc) or other tree species, where the harvested plant part is at a certain distance from the soil.

The amount of treated urine and processed faeces applied depends on the specific crop and soil status. Some guidelines on the production of different vegetable crops as well as estimated fertilizer requirements are given in the Philippine Allotment Garden Manual which can be downloaded from PUVeP's website (http://www.puvep.com).

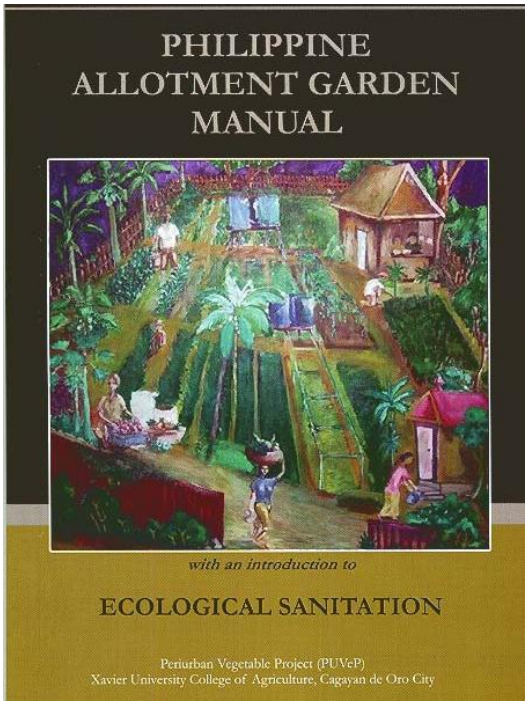

Fig. 21: Philippine Allotment Garden Manual with an Introduction to Ecological Sanitation (2008).

Fig. 22: Vermicast: Stored faeces after being vermicomposted with other crop residues (source: PUVeP, 2008).

Fig. 23: Treated faeces/compost is stored in bags prior to application (source: Wafler, 2008).

Fig. 24: The recommended amount of treated faeces/compost (usually 100 g/per hill) is placed in the planting hole and covered with soil (source: Wafler, 2008).

Fig. 25: An eggplant seedling is placed in the planting hole on top of the organic fertilizer (source: Wafler, 2008).

8 Further project components

Further project components are:

- Research on agricultural reuse, health and socioeconomic aspects of ecological sanitation
- Capacity building on ecological sanitation for the government, non-government and private sector.

- Integration of ecological sanitation in relevant academic curricula of Xavier University's School of Medicine as well as the Colleges of Agriculture and Engineering.
- Policy advocacy to decision makers such as assistance in drafting an executive order for the establishment of a technical working group on sustainable sanitiation for the city government of Cagayan de Oro, and consultancy for the Philippine House of Representatives in drafting a so-called "Ecosan Act" (June 2008).
- Showcasing of different ecosan technologies (UDDT, composting, vermicomposting, biogas and rainwater harvesting) at Manresa Farm to more than 1500 visitors from different parts of the Philippines as well as other countries. A highlight was the visit of Ms. Chin-Chin Gutierrez in July 2007, a multi-awarded Filipino actress and a Time Magazine Asian Heroine for the Environment.

Fig. 26: Ms. Chin-Chin Gutierrez at the UDDT in Manresa Farm (source PUVeP 2007).

9 Costs and economics

The material costs for establishing a UDD toilet may range from 25000 PhP (€ 410) for a double-vault UDDT to 12000 PhP (€ 197) for a single-vault UDDT, depending on the materials used. Labour costs for the construction are not included in this cost estimate because the work force was provided by the gardeners. However, it is estimated to be in the range of 5000 to 7000 PhP (€ 82-115) per toilet .

The UDDTs used in this project were purposely designed in a "luxurious", and therefore expensive, manner (e.g. use of tiles) since they were the first of their kind in Mindanao and served also as a showcase for decision makers. The costs presented also include "extras" such as information posters, floor mop, toilet paper as well as plaque of recognition for the donor.

Table 1: List of materials and costs (in currency PhP) for one double-vault UDDT (Source: Philippine Allotment Garden Manual - PUVeP 2008). 1 PhP = 0.02 €. Total sum: € 494.

Qty	Unit	Item	Total
1	unit	Ecosan bowl (incl. freight costs)	1,500.00
1	pc	Urinal (reused empty water gallon)	150.00
1	load	Sand (1 m^3)	770.00
1	load	Gravel (¾ ordinary)	1,100.00
20	bags	Portland Cement	3,564.00
		Coco lumber (assorted)	3142.70
160	pcs	Concrete Hallow Blocks – 4"x8"x16"	880.00
5	Length	Deformed bars – 8 mm Ø x 6m	176.00
16	Length	Deformed bars – 10 mm Ø x 6m	1,953.60
2	kg	G.I. tie wire - #16	105.60
3	pcs.	¼" x 4' x 8' – Marine plywood	950.40
3	pcs.	3/16" x 4' x 8' – Hardiflex board	1,056.00
2	pcs	Plain G.I. Sheet – gauge #26 (3' x 8')	473.00
8	pcs	2" x 3" – Hinge	80.00
2	pcs	3" x 3" – Hinge	50.00
7	pcs	Door pull - #5	126.00
1	kg	#1 – Common wire nails	50.60
1	kg	#1-1/2 – Common wire nails	48.40
0.5	kg	#2-1/2 – Common wire nails	23.10
3	kg	#3 – Common wire nails	132.00
1	kg	#4 - Common Wire Nails	34.00
0.5	kg	Flathead nails	30.00
3	pcs	1"Ø x 10' – PVC pipe blue	455.40
10	pcs	1"Ø – PVC blue – elbow 90°	209.00
2	pcs	1"Ø – PVC pipe – tee	83.60
1	pc	4"Ø x 10' – PVC pipe (orange)	297.00
1	pc	4"Ø – PVC pipe – Tee (orange)	74.80
120	pcs	Nipa shingles	420.00
0.5	bundle	Rattan Strip	24.75
4	sheets	Bamboo Mat (*Amakan*)	484.00
100	pcs	Tiles (8 x 8)	1,210.00
1	Can	Solvent cement – 400 grams	66.00
1	pc	Kitchen Sink – small	649.00
2	pcs	Water jug - 20 (transparent) for urine	440.00
1	pc	Soap case	22.00
1	pc	Plastic waste can (oval-small)	55.00
2	pc	Container (for sawdust and tissue)	220.00
1	pc	Container (for water)	110.00
1	pc	Water ladle	16.50
1	pc	Cup (for ash)	22.00
1	quart	Black paint	104.50
1	quart	Red lead paint	121.00
1	bottle	Paint thinner	27.50
1	pc	Safety hasp - #4	13.20
1	pc	Padlock – medium	62.70
1	pc	Barrel Bolt #3	13.20
1	gallon	Clear gloss varnish	418.00
1	bottle	Lacquer thinner	343.20
2	pcs	Paint brush – 2"	44.00
2	bundles	Bamboo	132.00
1	pack	Gloves	120.00
1	pack	Facial mask	110.00
1	pc	Shovel	220.00
0.5	kg	White cement	16.50
1	pc	Floor mop	275.00
1	pc	Toilet seat	260.00
1	pc	Plaque	500.00
1	pc	Info poster (Do's and Don'ts)	450.00
1	pack	Toilet paper	200.00
		Subtotal	**24,685.25**

UDD toilets with reuse in allotment gardens Cagayan de Oro, Philippines

10 Operation and maintenance

The gardeners assign on a rotational basis a person in-charge for maintenance of the toilets. The work is equally shared between men and women. The following guidelines are provided to the gardeners:

- Well-constructed and well-maintained UDD toilets do not develop bad odors, nor attract flies.
- Ensure that the urine is directly diverted and does not touch the faeces.
- The faeces are directed into a vault or container and are covered with appropriate dehydration materials (lime/sawdust mixture or dried soil, ash, or rice hulls).
- An ample supply of covering material must always be available.
- The faeces vault must always be kept completely dry. Avoid water from entering when cleaning the floor. Do not pour water on the floor since it may enter the storage vault.
- Always close the toilet bowl lid to prevent flies from entering.
- For people who are "wipers": throw toilet paper in separate trash bin; since the toilet is dry, paper will not decompose and it is not nice to look at later on.
- For people who are "washers": use the separate anal washing area next to the toilet bowl.
- Make sure that water is always available for anal and hand washing.
- Clean the UDD bowl with a rag. A stick with a damp cloth can also be used to clean the bowl.
- Brief "first time users" on the appropriate use and/or place "user's guidelines" inside the toilet for those persons who are not familiar with how to use a UDD toilet.

11 Practical experience and lessons learnt

Most of the gardeners are of the opinion that the toilet is very useful not only for them but also for their children, visitors, and customers of their produce. Some of the gardeners regard the toilet as something to be proud of since it adds beauty to the garden.

All of them consider the use of the UDDT as far better than open urination and defecation. Besides the missing privacy and washing facilities there is a high risk of being bitten by snakes and harmful insects. As the toilet uses no water for flushing, a septic tank for blackwater is not needed. Furthermore, natural fertilizer is produced for free.

Some gardeners, however, are not using the toilets because they prefer to go to their own toilets in their houses if they are located nearby. Other gardeners feel not yet comfortable using the UDD toilets because they are too shy – the UDD toilets are more "beautiful" than the toilets they have at home!

There was a need to improve the design of the urinal for men because sometimes urine remained in the urinal and produced odour problems. This was done by changing the original urinal (plastic waste bin) to a recycled water container (see Section 5).

Odour problems also occurred from the faeces vault when the faeces was not well-covered after defecation. Also, so-called "rollers" caused odour problems. "Rollers" occur when the faeces in the vault is not flattened and becomes the shape of a steep hill. Faeces deposited on the top of the steep hill roll down the slope and tend not to be covered. The problem was solved by flattening the faeces pile regularly. Dung beetles and mango flower beetles, who naturally entered some of the faeces vaults as their habitat and feeding ground of their larvae faciliate the automatic flattening of the faeces, hence no human intervention is needed in those vaults.

Most of the users found that the anal washing area was inconvenient to use since there is too little space available, it is very shallow and it is located too close to the wall. Changes in the design have now been discussed.

Most of the gardeners find the toilet bowl not suitable for children's use. Some gardeners allow their children to squat on top of the toilet bowl which makes the seats dirty. The cleaning of the toilet bowl is also a concern especially when there are many users who do not know how to use it properly e.g. when some of the faeces remain on the sides of the bowl after defecation. Better systems on cleaning and maintenance of the toilet are now being discussed.

A UDD squatting pan from India will be tested later in 2009, especially for children's use in selected schools.

The difficulty of separating urine from faeces is sometimes a problem: For women it is a more difficult task than for men to keep the urine and faeces separated during defecation, but can easily be managed with some practice.

12 Sustainability assessment and long-term impacts

A basic assessment 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 emphasized (weaknesses).

Table 2: Qualitative indication of sustainability of system components. 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)

	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		
• sociocultural and institutional	X			X			X		

Regarding the long-term impacts of this project, it can be said that the establishment of these gardens has significantly contributed to the improvement of food security of the participating families as well as of the neighbouring families

who can buy fresh, affordable and safe vegetables. Another advantage besides gardening is the fact that the gardeners collect the biodegradable wastes from the neighbouring households for composting.

This project has also served as a research and teaching facilitiy and the concept is being copied by others (see for example SuSanA case study on ecosan projects in Misamis Oriental implemented by WAND Foundation in the Philippines, www.susana.org).

13 Available documents and references

The website: http://puvep.xu.edu.ph/publications.htm contains numerous references for download, including those mentioned below.

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Case study of SuSanA projects

UDD toilets with reuse in allotment gardens, Cagayan de Oro. Philippines

SuSanA 2009

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