Keys for successful introduction of ecosan toilets: experiences from an ecosan project in Vietnam

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Abstract
Ecological sanitation (*i.e.*. ecosan) is considered to be a possible approach to not only sanitize human excreta but also recover nutrients for agriculture. Eighty-five ecosan toilets were introduced in Vietnam from 2002 to 2003 by authors and a Japanese NGO. In this paper, we (1) reviewed the project, (2) analysed the project from the aspects of the toilet construction, the toilet use and management, and disinfection performance by the toilet, and (3) developed keys for successful introduction of ecosan toilets. It was considered that this project was introduced successfully. Based upon the analysis, construction quality, effect of local conditions and self-fixing of the toilet were proposed for successful ecosan-toilet construction. In this project, at least 3-month education on the ecosan toilet was required. This education period may become a valuable reference for other ecosan projects and education on applying ash and handling urine was considered as key issues. At least 10-month retention of faeces was required to disinfect faeces in this project. This period may become a valuable reference and effects on retention time should be considered depend on local conditions.

Keywords
Ecological sanitation, construction, education, disinfection performance, Vietnam

INTRODUCTION

As of 2002, 69% of rural population in developing countries had no access to adequate sanitation (WHO and UNICEF, 2005). Providing basic sanitation is an urgent concern (Rockstrom *et al.*, 2005). At the same time, we should not miss the fact that human excreta contain much nutrients (Esrey *et al.*, 2001). These nutrients may be valuable for agriculture and should be recovered for agricultural use. Ecological sanitation (*i.e.*, ecosan) is considered to be a possible approach to not only sanitize human excreta but also recover nutrients for agriculture. Ecosan toilets have been introduced in various places throughout the world recently and most ecosan toilets are characterized by diverting nutrient-rich urine from pathogenic faeces.

Even if ecosan has a big advantage in terms of sanitation and nutrient recovery, a focus should be made on successful introduction and management of the toilets in order to maximize its performance fully. Ecosan may need more effort during introduction and management because most of ecosan toilets have urine-diversion systems different from general toilets. Experiences of ecosan introductions may be valuable resources for successful introduction and management of ecosan projects.

Vietnam is one of the countries suffering from the lack of sanitation and only 27% of the rural population has access to adequate toilets (WHO and UNICEF, 2004). The country has a history, in which human excreta have been used for agricultural purpose, especially in northern Vietnam. In order to prevent farmers from danger of faecal pathogens, health authorities had campaigns to spread double vault dry latrines since 1956 (Winblad and Simpson-Hebert, 2004) and 24.9 % of rural population in Vietnam was using double vault latrine as of 2002 (GSO of Vietnam, 2004). Human excreta is retained in the vault and then used for agriculture and some of the toilets divert urine from faeces. Thus, a urine-diversion concept has been recognized in some part of Vietnam. However, the toilets have not been used correctly in many cases and pathogenic excreta have been utilized for agriculture.

To address the sanitation problem in Vietnam, attempts have been made to spread sanitary toilets in rural Vietnam. An ecosan-toilet project was conducted and the Vietnamese-type ecosan toilet was developed in a rural area of Vietnam (Nghien and Calvert, 2000; Nga *et al*, 2001). Based on this toilet, we introduced 85 private-ecosan toilets in a minority hamlet of Vietnam from 2002 to 2003 as a part of rural development project by a Japanese NGO (Nippon International Cooperation for Community Development). This experience may be utilized for further ecosan project. In this paper, we (1) review the project, (2) analyse the project from the aspects of the toilet construction, the toilet use and management, and the toilet-disinfection performance, and (3) develop keys for successful ecosan-toilet introduction.

METHODOLOGY

After reviewing the project, the ecosan toilet introduction is analysed from the aspects of the toilet construction, the toilet use and management, and the toilet-disinfection performance as follows.

Analysis of the toilet construction

During nearly 2 months of 85 toilets construction, construction activities were supervise by the authors and the inappropriately constructed parts of the toilet were recorded through the observation.

After five-month use of the toilets, the construction state of each toilet was surveyed through the toilet-to-toilet observation and damaged parts of each toilet was recorded. In addition, we interviewed to households owing ecosan toilets on their countermeasures against the damages to their toilets. These investigations took about 2 weeks.

Analysis of the toilet use and management

After the first use of each toilet, we conducted house-to-house surveys on the toilet-use and -management conditions of each household 6 times during 3.5 months. The survey was carried out by a local health worker, who was one of the toilet users after she was carefully trained. The survey used true-or-false check sheets on 17 items related to toilet-use and -management conditions. Contents of each item were mentioned in the RESULT and DISCUSSION section. Then, the number of faults in the check sheet of each household was counted at each time during the six-time house-to-house surveys. Moreover, house-to-house interview and observation of toilets were conducted after 5 month use by the authors together with the investigations on the construction.

Analysis of the toilet-disinfection performance

Using the ecosan toilet in this project, urine is diverted from faeces. Diverted urine is used for agricultural use as it is considered to contain few pathogens generally (Hoglund, 2001). Pathogenic faeces are retained in each toilet chamber for disinfection.

We tested the toilet-disinfection performance during faeces retention in the same manner as

Carlender and Westrell (1999), and Chien *et al.* (2001). We prepared small bags with rectangular piece (45x 85 mm) of polyamide cloth with pore size of 20 μm, which contained 2 x 10^4 *Ascaris suum* eggs (the eggs are 45-70 x 35-50 μm) as indicators of faecal pathogens (**Figure 1**). The bags were kept in 0.05 M H_2SO_4 until use to suppress fungal and bacterial growth. Then, five toilets with full chambers were selected for the test, and 30 bags were buried in each chamber. The bags were recoverd from each toilet at different 8 times between day 152nd day and 297th day after burial.

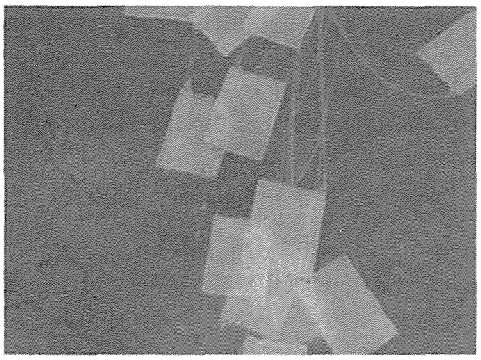

Figure 1 Bags containing *Ascaris suum* eggs

After recovered and washed, each bag was put in a H_2SO_4 solution and had been left for 4 weeks at room temperature (26-32 °C) due to the incubation of the eggs. The incubation period of four weeks was considered enough for the development of viable eggs to larvae. The bag was then opened and *Ascaris suum* eggs were scraped from the inside of the bag using a pipette. The eggs were placed in a drop of 0.1 % methylene blue on a microscopy slide. The eggs were distinguished between dead larvae dyed blue, alive larvae not dyed and non larvae in the eggs using microscopy. A suspension containing *Ascaris suum* eggs was stored in a refrigerator and it was used as a control of the viability.

During the incubation, alive ova may grow to larvae and then some of larvae may die (Carlender and Westrell, 1999). Eggs containing both dead larvae and alive larvae after incubation were considered to be infectable when they collected from the toilets. The ratio of infectable eggs was calculated as follows,

$$\text{Ratio of infectable eggs}(\%) = \frac{(\text{dead larvae} + \text{alive larvae})}{(\text{dead larvae} + \text{alive larvae} + \text{non larvae})} \quad \text{(Eq.1)}$$

PROJECT REVIEW

Project site and targeted people

The project site was located at Hamlet 5, DanPhuong commune, LamHa district, LamDong province in the central highlands of Vietnam. It has a tropical monsoon climate. The total population at the project site was 491 in 2002, composed of 84 households including 67 minority families. Most of them were living on agriculture.

Before the project was introduced, there were few toilets and most people defecated outside. The people suffered from a lack of sanitation and nearly 80 % of them were infected with intestinal parasites. As for water source, they shared some wells, most of which were shallow and simple wells.

In this project 84 toilets were introduced for 84 households, and one toilet was introduced at primary school for teachers living there. The toilet at primary school could not be allowed to be used by

students because management of the toilet was considered to become difficult if students use it.

The introduced toilet and its construction

The introduced toilets were not public toilets but private toilets for each. The toilet had urine-diversion system and was based on a type of ecosan toilet previously developed in Vietnam (Nga *et al.*, 2001). Before introducing the toilet into our project site, two different model toilets were constructed on the outskirts of the site. Through construction of the two model toilets and discussion with some leaders in the hamlet, the toilet introduced in this project was designed.

Figure 2 shows the outside of the toilet and **Figure 3** shows the urine-diversion squatting pan in the toilet. The hole in the centre of the pan connects to a urine container at the back of the toilet. At both sides of the pan, there are red and blue covers for each of two-faecal chambers under the pan. **Figure 4** shows mechanism to divert urine from faeces. As diverted urine is considered to contain few pathogens generally, it is used for agricultural purposes after dilution. Faeces are deposited with ash in one of two chambers under the toilet for disinfection. After an appropriate retention period, the faeces are removed from small doors at the back of the toilet and also used for agricultural purposes.

Under the supervision of authors, the construction was conducted by a local-construction company and members of each household helped the construction of their own toilet. The toilets were located near each house. The approximate construction cost for one toilet was 80 USD.

Figure 2 Outside of the toilet

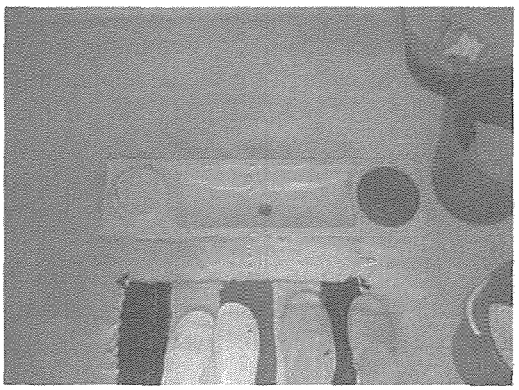

Figure 3 Inside of the toilet

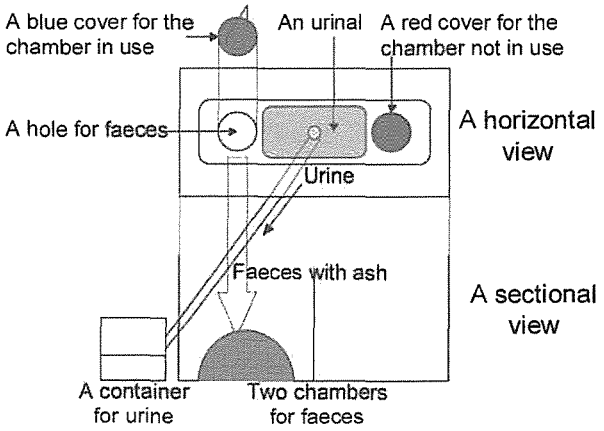

Figure 4 Mechanism of diversion of urine from faeces

Educating people on the use and management of the toilet

An orientation for households owing the toilets was held after the construction of the first model toilet. When the construction of the toilets for targeted households started, two lectures were held to explain how to use and manage the toilet: one for primary school students, the other for all-age people.

In addition, house-to-house instructions were carried out by a female local health worker under the supervision of the authors. She was a resident in the site, the leader of women union in the hamlet and one of the ecosan-toilet users. After each household started to use the toilets, she visited and instructed each household on the proper use and management of the toilet. The house-to-house instructions had been repeated at least every 2 weeks for about 3.5 months.

RESULTS AND DISCUSSION

Toilet construction

Construction state of the toilet. The construction quality of some toilets was not adequate. General inadequacies during construction were insufficient use of cement, and most of the construction inadequacies belonged to inadequate connection of roofs, back doors, ventilation pipes and urine pipes. These frequent adequacies may be suggested as checkpoints during ecosan-toilet construction.

After five months use, we found that 31 of 85 toilets had some damage. **Table 1** shows the damaged parts of the toilet and the number of each damaged part after 5-month use. Some toilets had multiple damaged parts. The major damage (67.6%) was found on the roofs of the toilet and **Figure 5** shows a toilet with a damaged roof. Damaged vent pipes and damaged doors were also found for some toilets. The most influential factor for the damages was considered to be the strong winds, which is one of the characteristic local conditions in the site located in the highlands. However, inadequate construction quality also may induce the damages so that the thickness of many damaged roofs was inappropriate. Consideration of local conditions and appropriate construction quality may be considered as key factors for successful ecosan-toilet construction.

Table 1 Damages of the toilets after five-month use

Damaged parts of the toilets	Number
Roof	23 (67.6%)
No roof	5
Damaged roof without repair	10
Damaged roof with simple repair	8
Vent pipe	9 (26.5%)
Door	2 (5.9%)

Countermeasures against damaged toilets. According to the interview to the toilet owners, they held meetings about the damaged toilets without authors or any external support, and they decided that each household should fix the damaged toilets by themselves with all possible means. Most of households repaired the damages and then kept using the toilets. **Figure 6** shows the toilet roof simply repaired by the owner after the roof was flown. Self-fixing of damaged toilets may be proposed as a key factor for successful ecosan-toilet management. However, some toilets were seriously damaged and hard to be repaired by owners. They were repaired by the authors and thin roofs were replaced by roofs with adequate thickness. The cost of all fixing by the authors was about 200 USD.

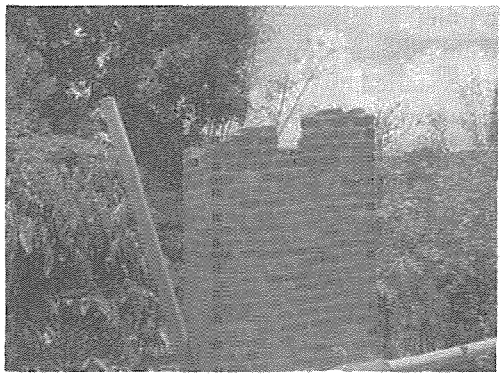

Figure 5 A damaged toilet

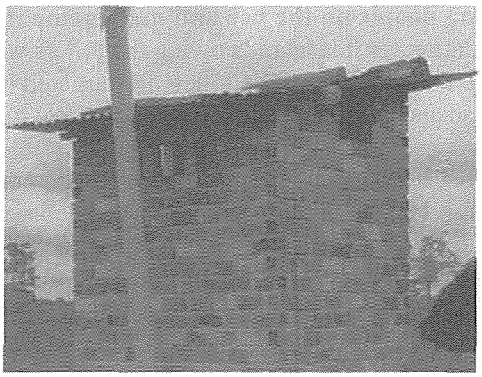

Figure 6 A toilet roof fixed by the owner

Toilet use and management

Five toilets different from other toilets. House-to-house interview and observation five months after starting to use shows that most of households used toilet but it was found that four toilets were not in use as toilets. One household moved to live in another place and two other households did not care about toilet use, and another household used the toilet as a hidden place to take a shower. In order to guide these households, except a household moving away, to use the toilet correctly, the authors, the local health worker and a chief of the hamlet visited and instructed the households. Some weeks after the visit, these three households started to use their toilets correctly.

The toilet built at primary schools has different conditions from other toilets. The toilet was built for teachers living there and the teachers did not full-year stay there. Because of educational aspects, the toilet at a school should be kept clean. However, the toilet was not in good conditions after 5-month use. The teacher reasoned that children played around/in the toilet and made it dirty although children did not use it for defecation. Then, teacher decided that the toilet must be kept locked to prevent children from entering.

General faults in use taken by the users. **Table 2** shows results of house-to-house surveys using true-or-false check sheets for 80 toilets, excluding toilets not in use 5 month after starting use and the toilet at primary school. The health worker did not check the item No.14 due to the difficulty of gathering water for dilution of urine in dry season.

The largest number of faults was in regard to ash applied to toilets (No.5, 7 and 9 in **Table 2**). The result indicated that the people tended to have faults related to ash for chambers. For the successful ecosan-toilet use and management, efforts of education should be focused on ash issues, especially ash preparation inside toilets. On the other hand, the conditions of inside chambers were considered not bad as seen from the percentage of items No. 2, 9 and 10 of 0.6 %. These results indicate that general condition of inside chambers is not bad although some people make faults related to ash.

Item No.6 was also accounted for large number of total faults (27.1 %). The result indicates that people often did not store water inside toilets for flushing urine. The climate seems to be the cause of this lack of action. The survey was carried out in dry season when water was scarce. Item No.13 is about urine handling and one of the major faults (13.3 %). This result indicates that people often left urine containers even after they were full. Proper urine handling can lead to nutrients recovery from human excreta. Education on urine handling may be a key for the successful ecosan-toilet use and management.

Table 2 Results of survey of toilet-use and -management conditions using true-or-false check sheets

No.	Checking item	No. of faults	%
1	Not clean floor	1	0.6
2	Faecal smell inside the toilet	1	0.6
3	Urine smell inside the toilet	0	0.0
4	Not covered faecal holes	2	1.1
5	No ash or no ash-container inside the toilet	73	40.3
6	No water or no water-container inside the toilet	49	27.1
7	No ash adding at the last use	2	1.1
8	Not enough ash during the using period	20	11.0
9	Maggots inside the vaults	0	0.0
10	Many flies inside the vaults	0	0.0
11	Using two vaults at the same period of time	0	0.0
12	Waste paper in disorder	0	0.0
13	Full urine container	24	13.3
14	Not using urine correctly	-	-
15	Using faeces before required retention time	0	0.0
16	Human faeces on the garden	0	0.0
17	Much litter on the ground around the toilet	9	5.0
	Total	181	100.0

Transition of the conditions of people's use and management. **Figure 7** shows the transition of total number of faults and households with faults for 80 households based on the result of the survey using true-or-false checksheets. The number of households with faults on toilet use and management decreased from 39 to 9 during six-time house-to-house surveys. It was considered that 88.8 % of households (71 of 80) adopted the ecosan-toilet use and management through the house-to-house instruction over the 3.5-month time period. This result indicates that education activities in this project were effective.

Close observation of **Figure 7** shows that there were no decreases in the fault number between the second and fourth surveys, but that the number decreased again by the fifth survey, which was done about 3 months after first toilet use. House-to-house instruction was considered to be required at least three months in this project. This period of time may become a good reference for educational activities in other ecosan projects.

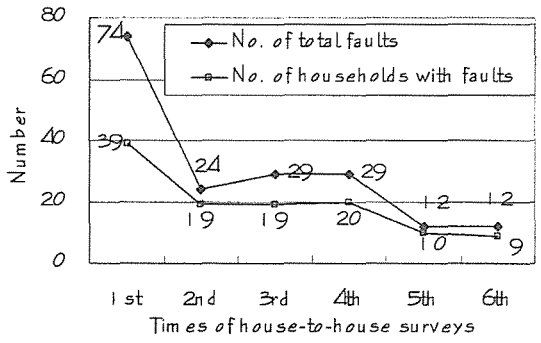

Figure 7 Transition of the number of households with faults.

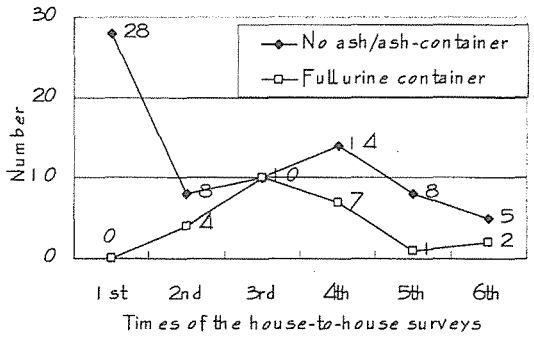

Figure 8 Transition of the number of faults of two items.

Between the second and fourth surveys, the numbers of faults of "No ash/ash container for faecal inside the toilet" and "Full urine container" increased as shown in **Figure 8**. It is considered that house-to-house instruction required more efforts in regard to ash preparation and urine handling after the user has started to use the toilet for some period of time. As mentioned in the previous section, education on ash preparation and urine handling may become keys for the successful ecosan-toilet use and management.

Toilet-Disinfection performance

The transition of the survival rate of *Ascaris suum* eggs in five toilets is shown in **Figure 9**. It took from 209 days up to 297 days, 249.4 days on average, to disinfect all eggs in the bags, compared that the ratio of infectable eggs of control keep about 90 %. It is indicated that ecosan toilets in this project could perform well to disinfect faeces.

The 95% confidence interval of days to disinfect all eggs was calculated to be between 207.6 – 291.2 days. Chien *et al.* (2001) reported that recommended retention time of faeces were 6 months based on their previous ecosan project. One of the influential factors in disinfection process of faeces is temperature (Schonning and Stenstrom, 2004) and the lower temperature of our project site might have resulted in the longer retention time. Compared that Chien's project site was located at coastal area and the average temperature of air during the period of observation was 32.4 °C, our project site is located at the highlands and the 2003 annual average temperature of the site was 21.2^{0}C. Thus, we conclude that the toilets required a 10-month faeces retention time for disinfection in this project and retention time should be carefully considered depending on local conditions.

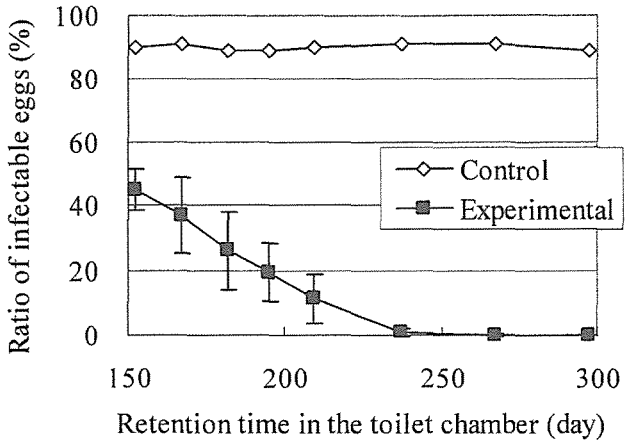

Figure 9 Transition of infectable ratio of *Aascaris suum* eggs

CONCLUSION

From the aspects of toilet construction, toilet use and management, and toilet-disinfection performance, it is considered that this ecosan project was introduced successfully. Based upon the experience gained from this project, we proposed some keys for successful ecosan-toilet introduction and management about the construction activities and self-fixing of the toilet, education activities, and retention time issues. Although ecosan-toilet introduction and management should be adapted to local conditions, these keys will contribute to the successful ecosan-toilet introduction.

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