

**Surveying the long-term feasibility and acceptance of different  
sustainable sanitation systems in Shaanxi and Yunnan**

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***Abstract:***

The non-governmental organisations Plan China and Yunnan Environmental Development Institute (YEDI) implemented sustainable and ecological sanitation (ecosan) to improve existing and not satisfying sanitation conditions in the Chinese provinces of Shaanxi and Yunnan. Different technical solutions like urine-diverting dehydration toilets (UDDTs), biogas-toilets, as well as double-urn toilets prove feasible without high-cost public sewerage and wastewater plants. The different systems close the loop of nutrients and provide the possibility to use human excreta as fertiliser in agriculture or to produce biogas for cooking. Yet whatever its level of technical excellence, the user proved to be the decisive factor for success or failure of the project in the long-run. Visiting the project sites, the authors examined why not every built toilet is still being used and why not every user is satisfied. They learned that not every user knows how to use it adequately and that it takes a long time to change people's habits, especially if one's privacy is affected. In order to achieve a high success rate with the improved means of sanitation among the population, they recommend to keep up training activities, supervise the users and to be available for advice over a long period. The experiences of the two visited projects show that it is very important to start working with young children in order to change the habits of the next generations as early as possible. The school sanitation projects in Shaanxi and Yunnan confirm this assumption.

## **1. Introduction**

More than 60% of the Chinese population lives in rural areas and access to improved sanitation and water supply is not a given in many areas. Children have been singled out as the group affected the most by sanitation-related diseases. Sustainable sanitation can break the cycle of diseases, protect the human health and improve environmental issues. In August 2009, the authors of this paper visited two sites, on which ecological sanitation (ecosan) systems have been implemented to fulfil sustainability criteria related to health and hygiene, environment and natural resources as well as socio-cultural aspects. The main focus of the field trip to Shaanxi and Yunnan was to investigate the long-term effects of the different ecological and sanitation systems.

Ecological sanitation is a new paradigm in sanitation which recovers human excreta as a fertiliser or soil conditioner, saves water and protects the environment due a reduction of untreated wastewater. The reuse of human excreta as a fertiliser has a long tradition in the Chinese agriculture and has, in comparison to other countries, a high acceptance in the population. Human urine rich in nitrogen and phosphorus can be used directly as a liquid fertiliser instead of a mineral fertiliser. Faeces can be used after a certain storage time or treatment as a soil conditioner. This can lead to higher food security of poor farmers. Another aspect is the production of biogas made of human waste.

## **2. Sanitation projects in rural China**

### ***2.1 Introduction of the project in Shaanxi***

The Shaanxi province is located in the region of Northwest China. The project location is mainly situated on the Loess plateau and is dominated by agriculture. The main products are grain, fruits, tobacco, cotton and vegetables. The soil is fertile, but the climate is semi-arid with rainfalls less than 600mm per year. The winters are very cold with temperatures averaging less than 0°C in January and hot summers with average temperatures of 26°C in July. Shaanxi has the lowest gross domestic product (GDP) of all provinces and especially in the small villages the income is very low. The visited project site is in Pucheng County, which is about 120 km Northeast of Xi'an.

Plan International, operating in China as Plan China since 1995, is a global non-governmental organisation (NGO). The main objective of Plan China is to reduce the poverty of children. While there are six county programme units, Plan China's head office is situated in Xi'an, the capital of Shaanxi. The Water and Environmental Sanitation (WES) project of Plan China was designed to improve sanitation, water supply and waste management in Shaanxi. Interaction and cooperation takes place on several levels: Plan China closely works with the rural community's government on the community level; it cooperates with other NGOs for sustainable environment and resource management and livelihood improvement; on the level of policy making, Plan China is involved as a rural development programme in cooperation with the central government in Western China. Starting in 2005, the WES project now encompasses more than 250 villages and 200 schools in six different counties. Prior to 2005, untreated excreta disposed of in old and simple pit latrines not connected to the sewer system had been causing diseases and environmental pollution, particularly of the groundwater. Since the implementation of WES, more than 18,000 urine-diverting toilets (UDDTs), over 3,600 biogas-toilets and 6,200 double-urn toilets have improved the aforementioned conditions. Plan China made the selection of the visited households and toilets.

## ***2.2 Introduction of the project in Yunnan***

The Yunnan province is located in the Southwest of China and the average income is one of the lowest of all provinces in China. The region has a strong focus on agriculture despite the fact that only less than 5% of its area can be cultivated as most of its plains and valleys are restricted by mountains—the average altitude is about 2,000 m. The main agricultural products are tobacco, rice, corn, cotton, and tea. The climate is mild with a long growing period. The average temperature in the winter ranges from 8 °C in January in the mountains to 27 °C in summer in July. Compared to Shaanxi, the average rainfall is very high with precipitation of up to 2,300 mm per year. The project described here is located at the Puzhehei Lake in Qiubei County 300 km southeast of the province's capital Kunming.

The “Puzhehei Upper Watershed Eco-Sanitation Project, Yunnan Province, China” is an ecological sanitation project of the Yunnan Environmental Development Institute (YEDI) co-sponsored by the Yunnan Environmental Protection Bureau (YEPB) to protect the Puzhehei Lake in Yunnan from pollution by human and animal waste. Having won the “International ReSource Award for Sustainable Watershed Management 2004” (US\$50,000) awarded by insurance company SwissRe, the project has also received financial contributions by the local government (US\$ 16,000). The project started in April 2005 with a feasibility study and site visits of other ecosan projects in China which saw old and simple pit latrines not connected to a sewer system; faeces were not treated and caused diseases and environmental pollution particularly watershed. The implementation of improvements started in August 2005 and was finished in June 2006. Beside replacing the old latrines with 104 urine-diverting dry toilets (instead of 20), one school toilet and 10 biogas pits (instead of 20), the project focussed on training, workshops and environmental education. The YEPB was organised the fieldtrip.

## **3. Technology**

There are three different ecological sanitation systems in use: 1) urine-diverting dehydration toilets, 2) the double-urn toilets and 3) biogas-toilets.

### ***3.1 Urine-diverting dehydration toilets (UDDTs)***

This technology is based on a squatting pan with two outlets. There is one for the urine and one for the faeces. It is a waterless, dry toilet, i.e. no wastewater treatment is necessary. The separated collection allows not only for a fast dehydration process of the excreta but the urine—pure or mixed with water—can also be used as a fertiliser in agriculture. To this end, a pipe at the outlet in squatting pan for urine is connected to a storage tank (Fig. 1). Two vaults to collect the faeces are below the squatting pan: one vault is being used while the other one allows the storage of faeces for at least six to eight months for dehydration and hygienisation. Once the vault is full, it will be turned around and the second one can be used. With a volume of 0.3m<sup>3</sup>, a family of five needs about one year to refill the vault. Each vault has one emptying opening, which is closed and sealed with bricks or boards made of wood or metal. A ventilation pipe helps to speed up the dehydration process and to avoid odours. It is recommended to cover the fresh faeces with ash or another dry material like sand to bind the liquids. Toilet paper or other sanitary products are supposed to be collected in a separate litter bin. Dehydration toilets can be installed outside the house or even inside. After a storage time of at least one year, the dried faeces can be used in agriculture as a soil conditioner or as a fertiliser (GTZ 2009).

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**Fig. 1:** Left: Squatting pan with movable cover. Right: Urine storage tank integrated into the steps. Example from Shaanxi. (Source: P. Feiereisen 2009)

The squatting pans on the visited project sites are made of plastic and the hole for the faeces is covered by a movable cap. The hole for the urine can be covered by a ping-pong ball to avoid odours. In China, a third outlet for anal cleansing is not common.



**Fig. 2:** Different UDDTs designs in Shaanxi and Yunnan. (Source: P. Feiereisen 2009)

The superstructure (Fig. 2) is made of bricks for privacy and to protect from the weather. The surface beside the squatting pan is usually tiled. Additionally, some of the households have a washbasin and richer households added a shower in the bathroom.

### 3.1.1 Situation in Shaanxi

Since 2005, more than 18,000 urine-diverting toilets have been installed. The visited villages in Pucheng County are Ganquanfang with a population of 1,300 and Jiawangzhuang with 1,800 inhabitants. As it is uncommon in Shaanxi households to have a toilet inside the house, most UDDTs have been placed in the courtyards or next to the houses. The superstructure is made of bricks and is usually customised. Plan China provided the squatting pan, the pipes and other material for the construction in the amount of 260-360 RMB (26-36€) per unit. The total costs for one UDDT are 700 RMB (70€) for a simple design and up to 1,500 RMB (150€) for an extravagant design. Some prosperous households integrated a shower and a washing machine which raised the costs to more than 3,000 (~300€).

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The house owners of the visited villages were all very satisfied with the UDDTs as they noted that these toilets were cleaner and less smelly; children felt less sick and the number of flies or mosquitoes has decreased considerably. Yet an evaluation by Plan China from 2009 (ZHANG, Y. et al. 2009) showed that not all of the installed UDDTs are in constant use: 43% of 219 surveyed households are using the new UDDTs exclusively, 13% are using a combination of the new UDDTs and the old pit latrine, and 44% testified to not using the new UDDT regularly. A contributing factor to explain this is the fact that the old pit latrines have not been destroyed yet. The report analysed further reasons for the low interest: 1) the decision for the new toilets were not made by the house owners themselves, but rather imposed on them by the village; 2) some users had not participated in the training and therefore did not know how to operate and clean them adequately; 3) some UDDTs were set next to the kitchen and the residual odours prevented the inhabitants from using the UDDTs. This could be remedied by Plan China by increasing training and post-supervision activities to achieve a higher acceptance rate among existing users and to win new users.

### **3.1.2 Situation in Yunnan**

In the two villages Xianrendong and Puzhehei, 104 UDDTs have been installed. It was planned to install only 20 units, but the reduction of the construction of the biogas-toilets and therefore the higher funds, allowed for a greater number of UDDTs. The total costs for one unit including labour costs and material are 930 RMB (~93€); the financial project support per unit was at 800 RMB (~80€) (YEDI 2006).

The authors have visited more than 20 UDDTs. Most of the UDDTs are in the courtyard or next to the houses. While most superstructures are in good conditions, regrettably, more than 80% of the visited toilets were in bad conditions, i.e. they were not clean, smelly and full of flies. The faeces in the collection vaults were wet and full of maggots. At least two are not in use anymore as they have deteriorated considerably. It seems that the users do not know how to use the UDDTs in the correct way, how to clean them and how to empty the vault. They do not attend trainings or workshops, probably because the project was finished more than three years ago in August 2006. However all of the house owners insisted, that there were very satisfied with the new toilets and attested to using them all the time. The house owners are using the collected faeces and the urine as a fertiliser in agriculture; there is no extra financial benefit, because most of the farmers have livestock and are using the animal waste, which is enough for the local production, instead of mineral fertiliser on their fields. In comparison to the reuse of animal waste, the amount of human excreta used is very small and helps only to protect the environment, not to save money.

### **3.1.3 UDDTs in a primary school in Yunnan**

YEDI/YEPD implemented an ecological school sanitation system at the primary school in Xianrendong consisting of 10 UDDTs and a water supply system (Fig. 3). The construction of the building is made of bricks and is divided into four UDDTs with squatting pans, one waterless urinal for the boys and four UDDTs with squatting pans for the girls in accordance to the affiliation of 180 pupils and 8 teachers to the school. The vaults for the faeces are placed below the squatting pans and can be emptied from the backside of the building. The teachers live on the campus and are responsible for the maintenance. They are allowed to use the dried faeces and the urinal as a fertiliser to cultivate vegetables and fruits for their own use.



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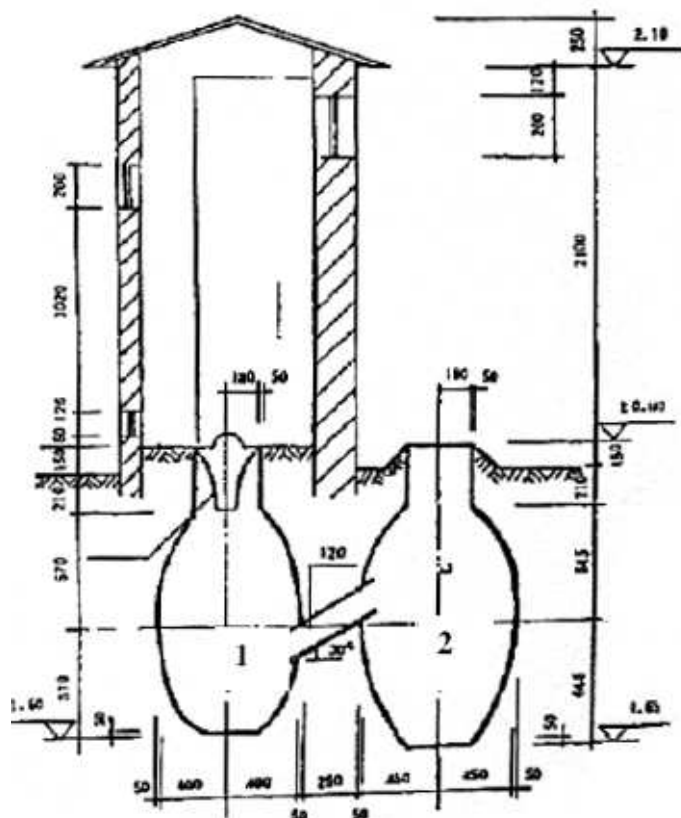
**Fig. 3:** School sanitation in Yunnan. Middle: Squatting pans. Right: Backside of the building. (Source: P.Feiereisen 2009)

The squatting pans are arranged in a row, divided by walls. The section for the boys and girls are also divided with two different entrances. According to regional customs, there are no doors installed. The new school toilet replaced a simple and unhygienic pit latrine. At the time of the site visit, the toilets were very clean, the litter bins had been emptied and the buckets were full of ash. The teachers showed impressively how the ecosan concept can yield the best result when used correctly. All children are using the toilets correctly, they understand the concept and internalise the hygienic education given by their teachers.

### ***3.2 Double-urn toilet (Double pit series latrine)***

The double-urn toilet follows a different concept. There is a common squatting pan with one outlet (Fig. 4), which is connected to two urns in the underground. Though there is no mechanical flush installed, a little water to flush is necessary. Faeces, urine and flush water are collected in the underground in two connected urns. Indeed resembling urns, these containers are made of bricks or pottery. Generally, the excreta are stored inside the first urn for 40 days. After that period most of the pathogens such as bacteria and parasite eggs are eliminated by the digestion process. If the front urn is full, the sludge flows to the rear urn which is mainly for the effluent. The rear one is covered with concrete slab to avoid odours and to stop the inflow of rainwater. If the rear urn is full (Fig. 5), it has to be emptied and its contents can be used as a fertiliser in agriculture (LI, Z. 2007).

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**Fig. 4:** Drawing of a double-urn toilet (Source: LI, Z. 2007)



**Fig. 5:** Squatting pan and full urn in Shaanxi. (Source: P. Feiereisen 2009)

### 3.2.1 Situation in Shaanxi

Since 2005, more than 6,000 double-urn toilets have been installed. The visited village, Xujiashuang, is situated in Pucheng County and has a population of 1,400. All households are connected to tap water, which was essential because of the low groundwater quality and over 95% have double-urn toilets. The improvement of the sanitation has been required to receive the water supply. Plan China has supported water supply, sanitation and a centre for the community, where women can produce clothes made from their own cotton. The centre is viewed as a meeting place, where courses and lessons are held to educate the inhabitants about hygiene and sanitation. The villagers have been very satisfied with the double-urn toilets, even if most of them are not using the sludge as a fertiliser on the fields. The reason for this is quite simple: they have to pay 15 RMB (~1.5€) for the emptying of the urn, if the company takes it away; if they want to use it as a fertiliser on their fields, they have to pay 20 RMB (~2€). On the other hand, the quantity would not be enough for their fields, and they have to buy mineral fertiliser anyway. That means the toilets allow a decentralised sanitation in the village, but without reusing it, it remains unclear, if this could be seen as an ecological sanitation solution, because the loop of the nutrients is not closed.

The owners of the visited houses are very satisfied with the double-urn toilets; the new toilets are more convenient and allow for more privacy. They explained that the double-urn toilets have a positive impact on health; according to them, especially children are less ill, yet specific data is not available. Plan China is still in contact with the villagers and takes care of the project and assisting when questions come up. The overall costs have been 600,000 RMB

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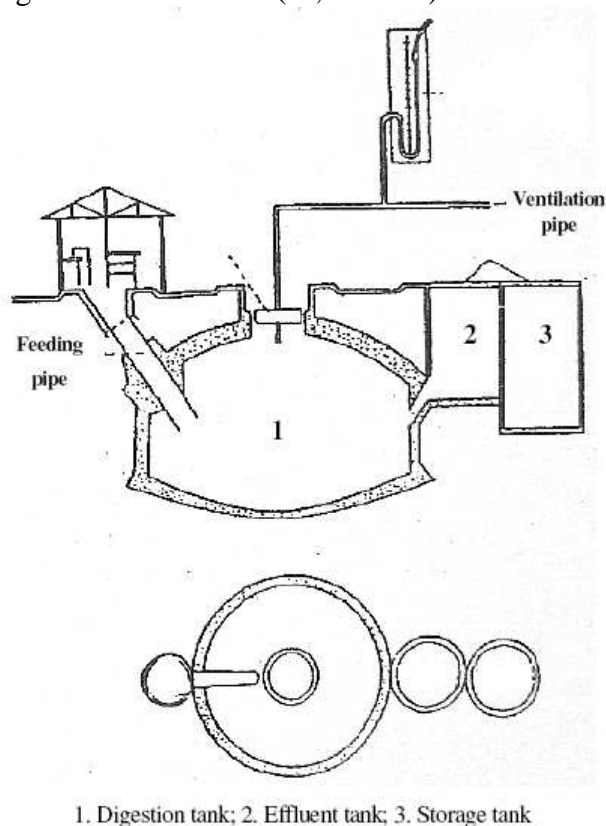
(~60,000€) including the centre. Plan China paid 300,000 RMB, the villagers contributed 100,000 RMB and the local government paid the difference.

### 3.2.2 Situation in Yunnan

No double-urn toilets have been installed.

### 3.3 Biogas toilets

The biogas toilet is connected with a pipe for the faeces to the digestion tank, like a septic tank or the faeces can be collected separately and be given manually into the feeding pipe to the digester (Fig. 6). The fermentation process takes place inside the tank. The gas can be collected and can be used for cooking or light. For each input, there is a drain on the other side. This slurry is a dark and odourless fertiliser and can be used directly in agriculture. The collected gas can be used for cooking or for lighting. Yet it needs the excreta of at least three families to produce enough biogas to supply the consumption of one family for cooking. The biogas plant can be additionally fed with animal waste or organic waste, like grass, straw or organic kitchen waste (LI, Z. 2007).



**Fig. 6:** Profile and vertical view of a biogas toilet. (Source: LI, Z. 2007)

The biogas-toilets are not only reasonable to reduce the environmental pollution due to human and animal excreta, they also allow using human excreta without any danger of diseases when it is used as a fertiliser. This way, the use of firewood and fossil fuels, like coal, can be reduced. The household has a monetary benefit due to the use of the self-produced biogas as well as the savings compared to commercial mineral fertiliser.

#### 3.3.1 Situation in Shaanxi

In Shaanxi, more than 3,000 biogas toilets have been installed. There was no biogas-toilet in the villages visited by the authors.



### **3.3.2 Situation in Yunnan**

YEDI and YEPD had initially planned to install 20 biogas-toilets with 8m<sup>3</sup> volumes, but only 10 biogas-toilets were eventually built. The reason is that the groundwater level in the region is very high and the chosen construction requires a groundwater level constantly lower than 1.5 m. The total costs for the construction including the labour costs for one household-size biogas-plant are 2,087 RMB (~208€), the project support per unit is 1,500 RMB (~ 150 €). There was also training on biogas production and management. According to the information given by YEDI, the acceptance and the satisfaction of the users is very high and the units are fully functional. It was not possible to visit a biogas-toilet during the field trip to Yunnan.

## **4. Conclusion**

The visited projects in Shaanxi and Yunnan show that ecological sanitation serves as a good solution to improve the sanitation in rural areas regarding sustainability criteria related to health and hygiene, environment and natural resources as well as socio-cultural aspects. The preparation and the cooperation with all stakeholders from the policy level to end-users of both projects have been ideal. The choice of the technologies and the implementation went according to plan and are optimal for their respective circumstances. But even if the technical side is excellent, it is the users who are the decisive factor for a success or a failure of the project in the long-term. It is very important to keep up training activities, supervise the users and to be available for advice over a long period; it takes a long time to change people's habits, especially if one's privacy is affected. The experiences of the projects show that it is very important to start working with young children in order to change the habits of the next generations as early as possible. The school sanitation projects in Shaanxi and Yunnan confirm this assumption.

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