A low-cost decentralized sanitary system basing on the incorporated vacuum collection and reuse of excrements and kitchen wastes

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Developing country where the research is being tested: China

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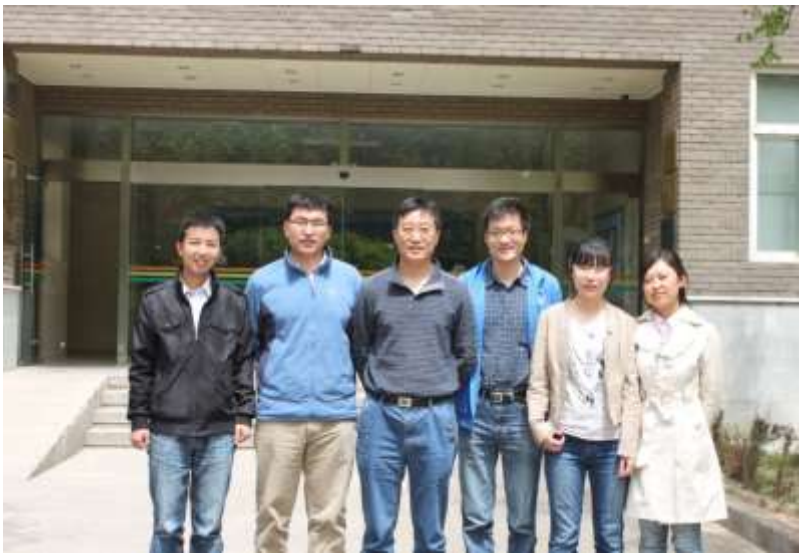

Short description of the project:

After 3 decades of rapid economic increasing, the decision makers of China care for the environment and the elemental well-beings very much more than anytime ago. Among the 0.9-billion population that have not possessed modern sanitation and sewage service, more than a half are unreachable to the centralized wastewater networks. It is estimated that the central and local governments should build decentralized sanitation systems for more than 0.5 billion people in next 20 years. A question should be answered by the Chinese researchers: need we follow the steps of the westerns to build the traditional wastewater and wastes treatment plants, which consume large quantity of energy, materials and resources just to degrade the remains from what we eat and excrete, or need we seek a more sustainable solution that consume less water and less energy as well as less money while maintain the same sanitary, convenient and organoleptic fit as the traditional ones? This solution must keep the merits such as water-flush and pipe-transportation, since people are not willing to live in the middle ages. We think vacuum sanitary appliances and sewage system as shown in Figure 1 is capable of this Job.

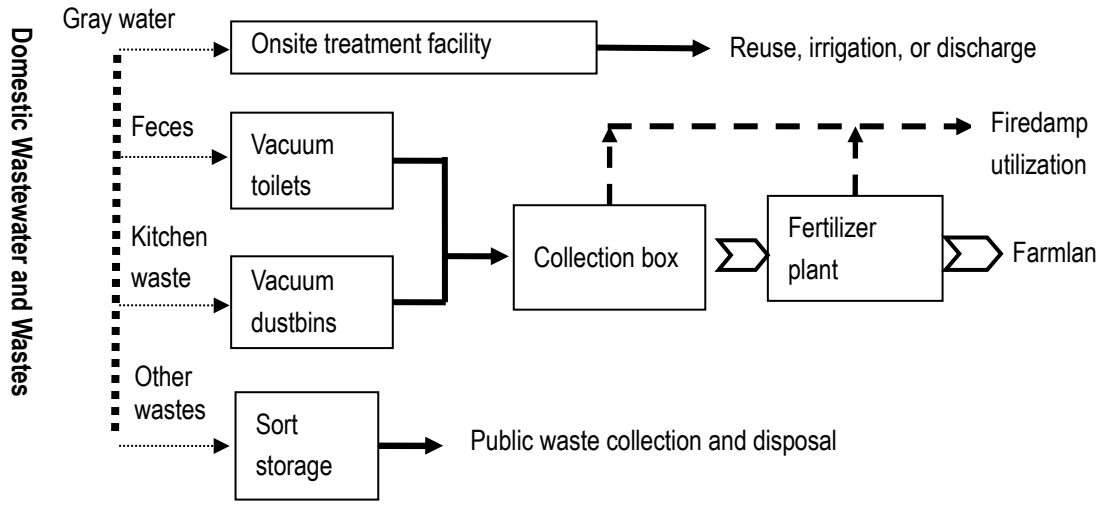

Figure.1 the schematic of the decentralized sanitation system basing on the vacuum collection techniques

Helped by the 10,000$ from the Bill & Melinda Gates' Foundation, we built a demonstrate engineering located in Chentang Village, Changsu City, Jiangsu Province in China. The engineering contains 41 vacuum toilets, 750m-length pipeline, a pump-station with a 24m3 tank for storing the blackwater and has served for 23 families over 2 years. The total engineering cost is 430,000 RMBs (~66,000$), which is not more expensive than the traditional system. A prototype vacuum collector for colleting heavy kitchen wastewaters and wastes was also tested in laboratory. If it being integrated into the vacuum sewage system, 80% of the challenges as well as the costs of the domestic wastes disposal will be saved. Recently cooperated with the villager committee, a 0.5-hectre plantation that only uses organic fertilizer was put into operation near by the pump-station. It was estimated 1267 m3 tap water and 5840 KWh energy was saved per year, comparing with the traditional water flush sanitary and wastewater treatment.

Whether the vacuum sanitation appliances and sewage system can serve for thousands and millions of people is not determined by the engineering cost, since the manufacturing cost of the vacuum appliances and equipments is expected to cut off 2/3 when large-scale use. The vacuum sanitation mode means a novel industrial chain with five links: vacuum manufacturing, engineering service, system maintaining service, organic fertilizer produce and usage. How to chain the five links and get policy support is the main challenge we face to.

We welcome any comments and feedback, and expect to cooperate with people in the same camp to promote the usage of this sanitation mode.

Goal(s): to build up a more affordable and sustainable sanitation mode which bases principally on vacuum collection of domestic wastes (excrements and kitchen wastes) and reused them as fertilizer on the premise of satisfying the people's demands on convenience and aesthetics.

Objectives (or activities or key research components): Build up a pilot scale verification system and fulfill the preliminary technical and economical feasibility study.

Research questions:

The technical and economical feasibility of the proposed sanitation mode.

Methodology:

(1) Built a demonstrate engineering;

(2) Operate and maintain the demonstrate engineering; collect the technical and economical parameters.

Results:

The pilot scale engineering was built at Chentang Village, in Changsu City, Jiangsu Province of China. It contains 41 vacuum toilets, 750m-length pipeline, a pump-station with a 24m3 tank for storing the blackwater. From June 19, 2011 when it being finished installation, the system has been serving for 23 families of villagers.

According to the operation record, from June 19, 2011 to March 20, 2012, the total used times of the vacuum toilets were automatically counted as 82746; the total volume of the black water collected was 70.5 m3, and the average flushing water used up by the vacuum toilets was 0.52 L per time; the total electric power consumption was 535.5KWh, averaged 31KWh per family per year or 0.006 KWh per time of flushing. Each toilet was averagely maintained 2 times in this period, mainly for clearing away clogging resulted by improper use. Most clogging happened in the first 4 months. With the villagers habiting to the correct usage of the vacuum toilet, the clogging happened less and less recently. The black water was cleared away by a local fecal treatment plant, with the service price of 5.1 US$/m3. Accordingly, the running cost of the pilot system is 526.7 US$/a, equal to 0.015 US$ per villager per day, not including the equipment and pipe-line maintaining cost. The pilot system is expected to save 1267m3 tap water per year comparing with the traditional water flushing toilets. The local tap water price is 0.4 US$/m3, so the pilot system is expected to save ~506.8US$/a of water bill.

We paid 2 times of visit to all the families using the vacuum toilets, and the consensus was “very satisfactory”: clean, convenient, no uncomfortable odors, no noise and water-saving. Before the pilot system was built, some villagers had used traditional water flushing toilets, and others had used latrine pits or closestools. The local groundwater of the village is importable now because of contamination.

The village had ever planned to build a sequencing batch reactor (SBR) for treating the wastewater, which engineering budget was 58,155 US$, and the running cost was estimated as 1462 US$/a. Considering the engineering and running cost of the vacuum source separation technology is promising to be lowered in future, we think it is a truly aspirational “next generation” product that everyone will want to use – in wealthy areas as well as developing areas.

Figure 2 vacuum pipe-line layout of the pilot engineering

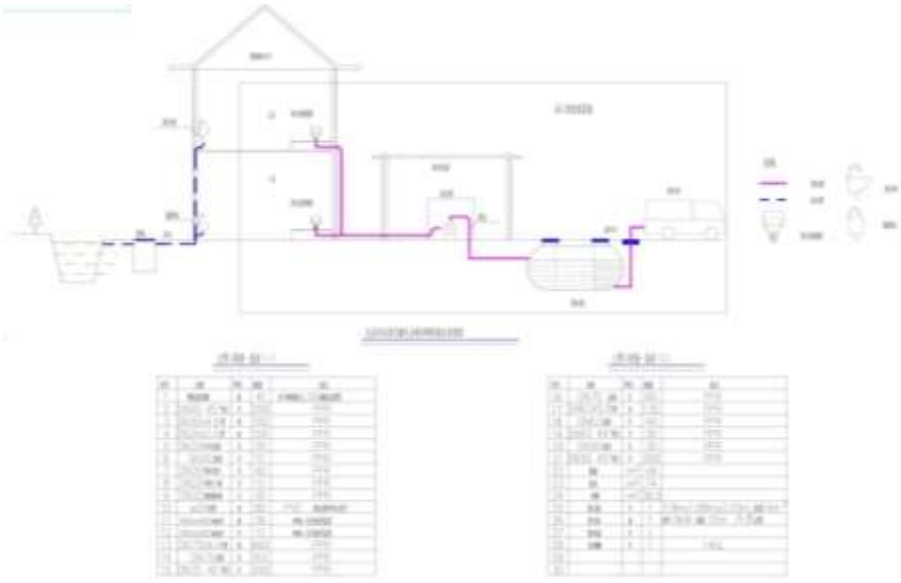

Figure 3 process layout of the pilot engineering

Figure 4 vacuum toilet installed in villager families.

Figure 5 vacuum pump-unit and buffering vessel

Future work:

The pilot engineering was just partly proved the feasibility of the proposed decentralized sanitation system mode as shown in Figure 1. There are still some challenges to close the loop of the sanitation mode shown in Figure 1. The main technical gaps lie in:

(1) Kitchen wastewater and wastes have not been collected into the vacuum system;

(2) Organic fertilizer manufacturing and utilizing are not realized.

Start and end date: April 20, 2011 through April 19, 2012

Grant type: Grand Challenges Explorations, Round 6 (GCE R6)

Funding for this research currently ongoing: Work on the project is continuing through a corporation plan including a company and the local government.

Research or implementation partners: Bureau of housing and urban-rural development of Changsu city (Jiangsu Province, China); Jiangsu town & village water technology service company.

Current state of affairs:

We have developed a prototype of vacuum washing basin for collecting kitchen wastewater and wastes (Figure 6).

Figure 6 the prototype of vacuum washing basin

As a continuing research plan, we are carrying through a field study aiming to use the black water as fertilizer on-site (Figure 7 and 8).

Figure 7 the onsite blackwater reuse system

Figure 7 the vegetables fertilized by the digested blackwater

Biggest successes so far:

Partly demonstrate the economical and technical feasibility of the vacuum source-separation sanitation mode in Chinese rural area.

Main challenges / frustration:

(1) the prejudices that think vacuum collection system being too expensive and difficult to operate and maintain.

(2) Lack of enough support from manufacturer. Maybe the biggest challenge is how to construct a close loop of the industry and business: vacuum equipment manufacturing, system construction and running, organic fertilizer manufacture and organic agriculture. Such a close loop can only be tested in an area scale.

Links, further readings, etc:

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