The Eco-dry Toilet in Taiwan Recreational Resort

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ABSTRACT

The traditional toilet leaves serious water pollution problem by increasing amount of tourists especially at the recreational resort. In Taiwan two sets of eco-dry toilets were opened to public since November 2003 in Yushan National Park. For the high altitude, low temperature and no water or power supply, the traditional flushing toilet could not be used. The two eco-dry toilets were designed by ecological waste treatment process. It is to treat the urine and faeces separately, urine was treated by soil absorption and microbiological treatment, faeces were mixed with saw dust and by solid fermentation to make compost. After one year of continued monitoring, composting chamber temperature is 10 °C higher than the ambient temperature for microbiology reaction but the small volume compost pile can not reach high temperature for germicide. Yet the composition of the compost matched the fertilizer standard. The soil analysis indicated that chlorine content had no obvious difference after urine was treated by soil absorption treatment. The toilets were finished by well design, regular cleaning and maintenance; after more than 38,000 services it was also approved that the dry toilet is a good choice for the recreational area.

INTRODUCTION

The Yushan (Jade mountain), 3952 meters, is the highest mountain in Taiwan and also the most popular trail with more than 40,000 visitors annually. To improve the environment and provide a better service, two eco-dry toilets had been built in the

8-hours trail to the Pai-yun lodge in 2003 and a project was monitoring the toilet working efficiency in 2004 all year round. The eco-dry toilet was located inside Yushan National Park, so the building was designed to match the scenic of the park with wooden building and finished by ecological engineering. The toilet was equipped with urine/faeces diverting stool (Figure 1) and they were separately treated.

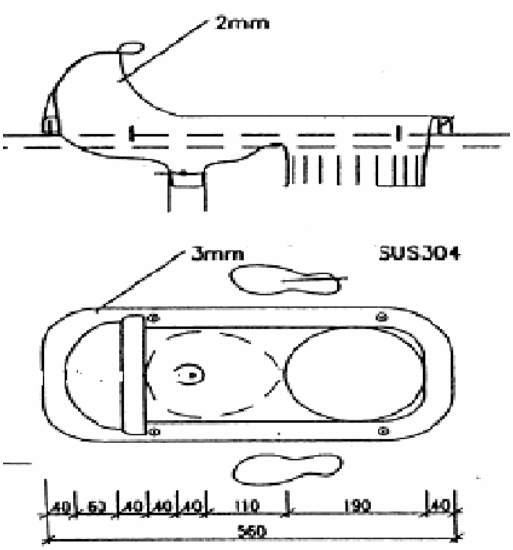

Figure 1. The urine/faeces separating stool.

Urine was treated by microbiological treatment and soil absorption by a 30 m long seeping pipe (Figure 2), which was 60 cm underground.

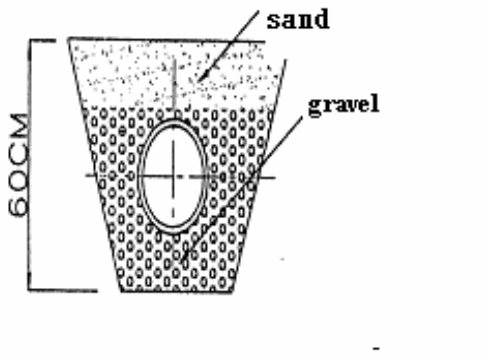

Figure 2. The seeping pipe.

The faeces were mixed with sawdust and rotten leaves. User has to turn the handle of the agitation shaft and blade to mix faeces and saw dust for composting. The solar cell and wind turbine generate power for lighting and ventilation inside the toilet, the stool was made of stainless steel and could be removed out easily for cleaning. After one year

of monitoring, it was approved that the two toilets work well in a region where there is no water, no power and freeze occurs every now and then. It was approved also that the compost is a good fertilizer. There are two more sets of dry toilets that have been finished in Taiwan 2005.

METHODS

The best composting condition is with a water content of 60 %, C/N = 20, with sufficient oxygen and micro-organism. For better treatment efficiency, saw dust was added as a bulking agent and water content was adjusted to improve the faeces composting process. Composting chamber was made with insulation material to avoid the inside temperature from dropping. Rain water was collected for further cleaning use and green power was used for the lighting and ventilation. The major parts of the system are listed in Table 1.

Table 1. The major parts and functions of the dry toilet.

Main parts	Material	Function
Bulking agent	Saw dust, local rotten leaves, mature compost	Water adjustment, microorganism seeding
Fermentation tank	Shaft, gear reducer, handle	Mixing, aeration, fermentation
Temperature control	Chamber heat insulation	Keep temperature
Ventilation system	Fan, green energy	Exhaust toilet air, supply oxygen to microorganism
Safety device	Lighting	Light
Rainwater collection system	Filter, water tank	Cleaning use
Power generation	Wind turbine generator and solar cell, battery	Ventilation and lighting

The one year of monitoring job included assessment of attendance, reading the tank and ambient temperature every month, and analysis of the soil and compost to evaluate the system once in a year.

RESULTS

1. Attendance number was different every month. For security reasons the park was closed during snowy season. Park was closed in January and February each year. For shorter time park was also closed twice due to a typhoon in July and August. Checked from the attendance counter was that more than 38,000 visitors used these toilets in 2004. Attendance, the number of usage with services is presented below in Figure 3.

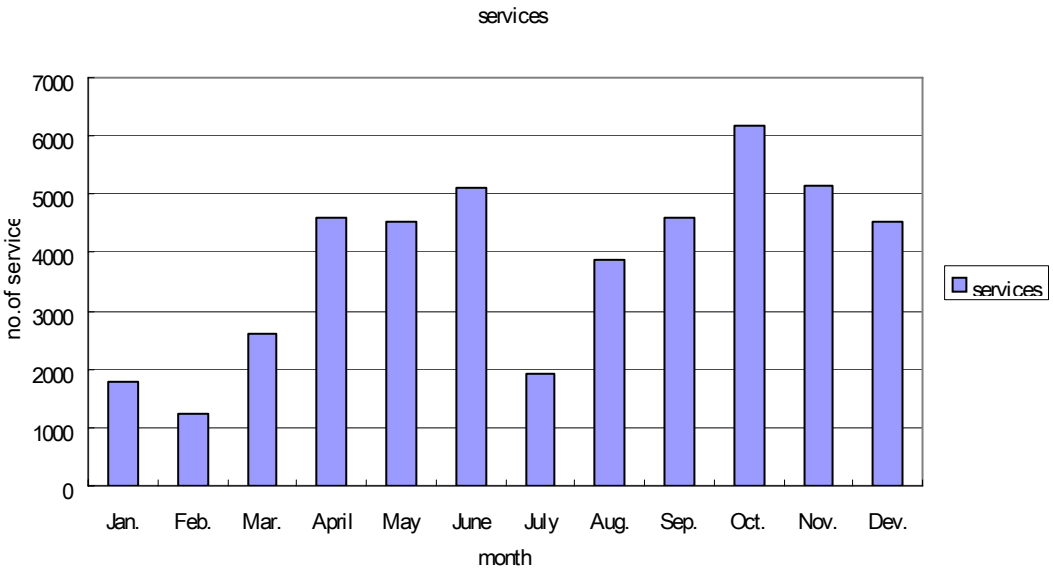

Figure 3. The attendance to dry toilet services in 2004.

2. The dry toilet was designed to work by solid fermentation. For better treatment efficiencies, faeces were mixed with sawdust, local rotten leaves and mature compost. The local rotten leaves contain with low temperature microorganism and they will boost the start up operation at low temperature. For maintaining the microorganism inside the tank, only 1/3 of compost was cleaned and changed inside the tank every 6 months. The temperature indicates the microorganism operation. Figure 4 below shows that on the first 2 months the temperature is the same with ambient temperature, but the compost temperature is 10 °C higher than the ambient temperature at the third month. It also means the microorganism worked well at that time. But temperature can not reach 60-70 °C for germicide, the unwanted microorganism, which would mean that the compost should be

further treated or dumped in a safety landfill site.

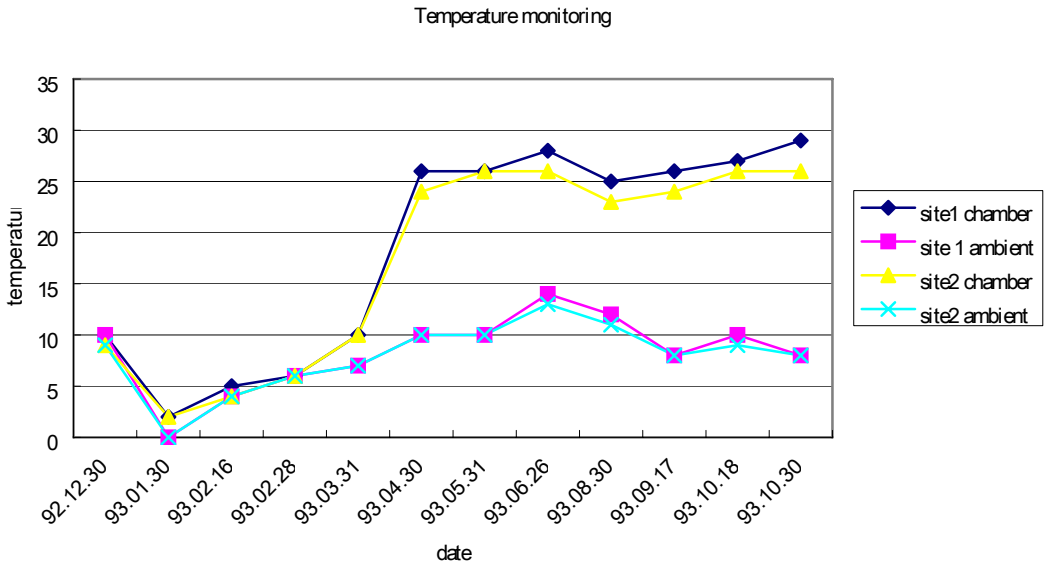

Figure 4. The compost and ambient temperature.

3. The overflow water from water catchment tank was used to dilute the urine and flush the urine out in the seeping pipe. To assess the urine's effects to the local soil, the chlorine content of soil was analysed from the seeping pipe 5 m and 0.5 m away at each toilet site. In Table 2 the chlorine content is almost the same in this area. It shows no apparent effect by urine after the toilet operation. Urine's effects should be monitored for a longer time to find out the over all assessment.

Table 2. Soil chlorine content.

Location and chlorine contain	Site 1		Site 2	
Location	5 m	0.5 m	5 m	0.5 m
Chlorine (ppm)	75.8	81.9	90.6	83.0

4. The compost in the operation chamber was removed and changed about 1/3 every 6 months. After analysis of the compost, it was shown that the chlorine contents were 4250 and 3920 ppm, accompanied by faeces and urine, but this was not included on the list of the fertiliser regulation. The major content of N, P, K and 8 major heavy metals matched the requirements of fertiliser codes in Taiwan. It means the compost could be a good fertiliser after mature composting process.

Table 3 shows results of compost analysis.

Table 3. Analysis of compost.

Integrant	Unit	Site 1	Site 2	Fertilizer codes	Method
Chlorine	ppm	4250	3920	-----	NIEAW415.5OT
TOC	%	13.6	13.6	-------	Walleye Black
Total Nitrogen	%	1.69	2.59	3 0.8	Regular Kjeldar Method
Dissolved Nitrogen	%	0.14	0.22	-----	Kjeldar Method
Copper	ppm	27.2	29.3	150	NIEA S321.63B
Mercury	ppm	0.498	0.619	2	NIEA M317.01C
Lead	ppm	1.51	4.63	150	NIEA S321.63B
Zinc	ppm	34	106	500	NIEA S321.63B
Cadmium	ppm	0.26	0.52	5	NIEA S321.63B
Nickel	ppm	13.2	9.3	25	NIEA S321.63B
Chromium	ppm	65.9	44.9	150	NIEA S321.63B
Arsenic	ppm	1.27	2.3	50	NIEA S310.62C

DISCUSSION AND CONCLUSIONS

The cesspool is the most popular toilet wastewater treatment process in Taiwan, but the low efficiency also makes it a serious water polluter. Most of the recreational resorts in Taiwan are located in water protection zone. A non-polluting treatment process is needed to treat toilet waste. The eco-dry toilet is a new treatment process in Taiwan, but from the one-year of monitoring, it showed that the dry toilet works well and has been accepted in Taiwan recreational resort. The routine cleaning and maintenance are necessary for the best service. The manual agitation and mixing shaft can increase the faeces and saw dust mixing, leading to better results. The compost is approved to be good fertiliser; it could be used for example in gardening in the park for the sustainable development.

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