



VIETNAM'S SANITATION SYSTEM

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The Vietnamese toilet is of interest for several reasons. It is probably the only system which was successfully applied on a national scale in a developing country. This was possible because of its simplicity in use and construction. The system made significant contribution to the environmental care and agriculture in Vietnam by recycling human excreta as fertilizer. Its significance for public health care is also very considerable. The Vietnamese method of excreta disposal is most remarkable since it follows completely different principles of pathogen destruction and mineralisation of organic matter compared to systems used elsewhere.

The great difficulty in public sanitation encountered throughout the Third World certainly justifies some attention for the successful Vietnamese methods, especially since the system is unique in its applicability in flood-prone areas, as well as in places without piped water supply.

The few publications about the Vietnamese Toilet so far available in the west have been limited to short descriptions of the construction and use of the toilet but little information has been available about the actual process performance. In this article we would therefore like to concentrate on these aspects.

Anaerobic composting

The system is characterized by in situ treatment of excreta, separation of urine and faeces, anaerobic composting and family size units.

The Vietnamese toilet is a double-vault system or a discontinuous toilet. There are two tanks one is used as a privy while the other has been closed and is used for composting of the faecal matter.

The Vietnamese Toilet requires that faeces and urine are deposited in different containers. After each use of the toilet some ash or lime is thrown on the fresh excreta to absorb humidity and to eliminate the smell. Toilet pare can be dropped into the vault. The lid is carefully replaced on the opening after each use. When the tank is full the material is levelled off with a stick and all is covered with an extra layer of ash. The opening is then sealed hermetically with mortar and marked with the date to assure a sufficient treatment

time. In the Vietnamese Toilet organic matter decomposes in two phases: as long as the toilet is in use there is ample oxygen available. Since the faeces are always covered with ashes the pile remains porous and aerated and the process is aerobic. After the ault is closed the oxygen is rapidly exhausted and the process becomes anaerobic. The Institute of Hygeine and Epidemiology in Hanoi monitored the development regularly and analysed the various processes involved in this type of toilet. Since food tradition and living conditions vary and there are different construction methods in the various regions, the Institute established a number of field stations for such analyses.

The process

The Vietnamese Toilet has been developed as a part of the National Institute of Hygeine and Epidemiology. The Institute started in 1956 to study old and new methods for the collection, transport and treatment of human excreta and its use in agriculture. Data about the qualities and composition of human excreta were collected:

TABLE 1

Human excreta composition

Annual excreta quantities per person: ca 500Kg
Containing: 1.07% N
5.7% Organic matter
1.3% Inorganic matter
0.26% P_2O_5
0.22% K_2O

It was noted that human excreta is rich in organic matter in comparison with excreta of domestic animals. Treatment should therefore not only be useful from the health point of view that is effective in pathogen destruction but also for agricultural reasons: achieving a satisfactory mineralization and conservation of the valuable organic matter. One of the first methods propogated in Vietnam was aerobic composting of human excreta with agricultural waste in windrows on a floor of rammed earth or concrete. The windrows were covered with a thatch and mud layer of ca 20cm. Temperatures of 70°C could thus be reached and the process was completed after three weeks. But all the known disadvantages of windrow composting were experienced: transport and handling of fresh excreta, fly breeding and

very disturbing odours. It was therefore soon decided to try anaerobic composting methods. An interesting development at this stage was the research on the antibiotic effect of carbon-rich material added to the excreta. Household refuse, agricultural waste and leaves were studied. Two types of leaves, *Rhizohora* and *Aegiceras* were chosen because of their iodine content, while the leaves of the *Melia Azadarach* were tested because of their antibiotic properties. The results were encouraging and in later developed composting methods these leaves were used. The first experiments with anaerobic composting were executed in pits of 150-200cm depth, where alternating layers of excreta and carbon-rich material were buried under a cover of straw and mud. It was found that after four weeks a satisfactory level of pathogen destruction could be reached. It was also found that a 10% additive of lime or superphosphate would reduce this time to ten days. The positive results of nitrification and pathogen destruction in anaerobic composting encouraged the Institute to attempt composting directly in the toilets in order to avoid the handling of fresh excreta. A multi-disciplinary team in the Institute under Dr Nguyen Dang Duc then set out to develop the Vietnamese Toilet. The first publications about their work appeared in the series Vietnamese Studies. The toilets were first called "Double Septic Tanks". Later the name "Double Septic Bin" was used. In this article we shall simply use the name "Vietnamese Toilet". A major question was whether composting of very small quantities of faeces such as produced by one family would be feasible in view of the problem of odours and of heat loss which retards the composting and changes the character of the process. It took time to solve these problems. An interesting additional requirement was to develop a toilet which would satisfy the peasants' timing for applying fertiliser to the fields. The use of human excreta in agriculture is so general in Vietnam that farmers often proved unwilling to wait for the treatment if it would interrupt the agricultural cycle. The decisive factors for determining the dimensions of the toilet were therefore the minimum composting time possible and the volume of excreta produced during the same time by an average family.

These two factors would assure the peasant the shortest possible cycle to make a safe compost available. The attention of the Institute turned therefore to the choice of suitable carbon-rich material to shorten the cycle. The final product is determined by the composition of the excreta itself and it was noticed that the composting process developed better with a dry rather than a humid mixture. It is essential to avoid flooding of the vault, but it is not easy in a hot climate. Moisture content should either be reduced by adding moisture-absorbing materials or by separating urine from the mixture. This last step proved

to be effective. It was also found that fly control would be easier in a dry mixture. Separate urine treatment was not considered very risky from the health point of view. For the volume of the vault it would mean a reduction by 90%. The separation of urine from faeces has much effect on the composting process. Firstly great quantities of water are avoided: urine has a moisture of 93-96% (see Gotaas 2). In this way the faeces can be composted without arrangements for drainage or ventilation. The quantities of nitrogen and potassium (as K_2O) are approximately equal in faeces and urine as excreted per person per day. The quantity of calcium (as CaO), phosphorus (as P_2O_5) and carbon in urine are respectively only 50%, 25% and 10% of those discharged in the faeces. It is worthwhile to recover these materials as well.

TABLE 2

Excreta composition (calculated from Gotaas' figures)

Dry weight in grams per person per day

	Faeces	Urine
N	6.75-16.9	7.5-13.3
P(P_2O_5)	4.05-14.58	1.25-3.5
Potassium (as K_2O)	1.35-10.75	1.5-3.15
Carbon	54.00-148.5	5.5-11.9
Calcium (as CaO)	5.40-14.5	2.25-4.2

Urine handling

Urine is separated from the main treatment tank to simplify the composting process. The large quantities of fluids are handled separately and the acidity and nitrogen content in the composting pile is reduced significantly. Consequently much smaller amounts of carbon-rich material are needed to reach the C/N ratio required for composting. But what are the health aspects of it? The higher temperature now reached in the composting vault promotes the pasteurisation effect of the composting process and makes it therefore more efficient. The urine itself however has to be treated as well. The original method is simply to drain the urine into a water-filled jar outside the toilet building. The one-to-four dilution reduces the smell and the mixture is used to water the garden. In later designs a special receptacle filled with lime and ashes receives all the urine. In this arrangement no flies or odours are detectable even if the receptacle lacks a cover. There are few diseases which are transmitted through urine: bilharzia, typhoid and leptospirosis.*¹⁵ It can therefore be argued that the health risks related to urine are insignificant compared to those caused by faeces. The Vietnamese hold that urine, after absorption and retention in lime or ashes can be safely used as fertiliser. There are however no data available to support this claim.

Further experiments were thus based on urine

separation and on the studies of effects of carbon additives. Since the aim was to develop a toilet with composting in situ it was necessary to know the effects of the additives both during the time the toilet was used and during the composting period. Household refuse, powdered earth, leaves and straw were examined. Although the results were encouraging, a shorter composting time than two months could not be achieved with these and the search for better additives continued. Powdered lime, quick lime and kitchen ashes were found to give good results. These additives would increase the composting temperature, improve fly control and reduce odours in the toilet. The general availability of kitchen ashes to rural households was an important consideration; it would increase the acceptability of the toilet.

Since only faeces would require a lengthy treatment process the reduction of quantities made a great difference. Dr Nguyen Dang Duc calculates that the annual quantities of faeces per person amount to 48Kg whereas the figure for urine is 438Kg. In other words only 10% of the excreta has to be composted. The treatment of the other 90% is much easier.

In comparison with the 48Kg which have to be treated per person annually by the Vietnamese method it is interesting to note that the annual quantity of waste water per person in North America is 800 times as much: 40 000Kg. The five gallon flush multiplies the treatment enormously.

The Vietnamese emphasise that adding ashes is essential for the process. Gotaas argues, while discussing aerobic composting, that great quantities of ashes should be avoided during the composting to prevent the loss of nitrogen. The Vietnamese on the other hand hold that anaerobic composting in closed containers retains many of the gases which are lost in an open process. Ammonia for example dissolves in the water suspended in the pile and is useful as a fertilizer as NH_4Cl , $(\text{NH}_4)_2\text{SO}_4$ and $(\text{NH}_4)_3\text{PO}_4$. Ashes do absorb many of the aromatic gases. The concentrations of NH_3 and SH_2 measured in the vault were only 0.007 mg/l² respectively. After three weeks composting no traces of these gases could be found. The effect of ashes and other additives on pathogen destruction was tested in relation to Shigella, Salmonella, Vibrio cholera, ascarsis and many other pathogens.

TABLE 3

Additives and pathogen destruction for anaerobic composting - destruction in days

Pathogens	1	2	3	4	5	6	7
E Coli	62	60	35	56	20	0.34	21
Sh Shigae	12	10	10	9	8	0.7	7
S Typhi Vi	24	15	12	12	12	0.4	14
Vibri Chol	9	8	3	7	7	0.24	1

Key to additives: 1 = excreta only
2 = powdered earth
3 = Melia Azadarach
4 = Household refuse
5 = powdered lime
6 = quick lime
7 = kitchen ashes

The effect of the additives is noticeable. Kitchen ashes show about the same values as powder lime and are available everywhere in the rural areas. Ashes also have a marked reducing effect on the occurrence of flies. The temperatures in the vault during the aerobic period are a few degrees higher than in the toilet room itself. The humidity is also slightly higher in the vault. After closing the vault hermetically the temperature rises dramatically: in five days from 30°C to 45°C peaking after twenty days at 52-60°C and then slowly dropping off after 45 days to the original temperature again. The method used to measure temperatures is to mount water-filled glass tubes through the construction into the pile. During the composting period thermometers are introduced into the tubes to take the temperature of the surrounding material.

The Ministry of Public Works¹⁶ informed us about the test results concerning pathogen survival and gave some details on bacteria and parasites. Salmonella, Salmonella typhi, Para A and B, Shigella, Flexner and Sonnei were absent from the compost. Special attention was given to Escherichia Coli, a very resistant pathogen.

TABLE 4

Survival of E Coli

Total before composting	11 110 000 un.
After one week	1 110 000 un.
After four weeks	100 un.
After 6-7 weeks	traces

Of the common parasites, ascaris was studied carefully because of its high resistance. The effect of the composting process on the survival of intestinal parasites is of great importance since about 70% of the population were reported in 1958 to be carriers of Lumbricoides Ascaris, 35% were carriers of Duodenalis Ankylestema. Samples from the third and fourth composting weeks showed a high occurrence of Ankylestema larvae and a 35% reduction of the eggs. The larvae do not survive the seventh and eighth weeks. Of the remaining eggs 50% can no longer develop into larvae. The Vietnamese sources conclude that a total of 85% of the parasite eggs are destroyed after an eight week composting period. The destruction of parasite eggs is closely related to the type of additive used for the composting. If lime, phosphate or kitchen ashes are used 50% of the Ascaris Lumbricoides eggs - the most resistant

parasite - degenerate, while all the larvae are destroyed.

Dr Nguyen Dang Duc informed us that the general application of the Vietnamese Toilet must be credited with the sharp reduction in the occurrence of intestinal diseases as demonstrated in the table below.

TABLE 5

Incidence of intestinal diseases

Bacteria and parasites	Incidence(%)	
	1958	1978
Shigella disentry	12 - 13	1.2 - 1.7
Salmonella	6 - 7	0.1 - 0.6
Coli GEI	4.5 - 12	1.2 - 1.8
Ascaris Lumbricoides	60 - 80	15 - 35
Trichocephalus	40 - 45	10 - 12
Ankylostoma Duodenalis	20 - 25	10 - 15

Mineralisation of organic material can be determined in different ways and is used to indicate the stabilisation of the decayed excreta. The different methods do not give compatible results and there are no general methods to compare mineralisation of composting and water-borne excreta treatments. In the last disposal method Biological Oxygen Demand (BOD) is used to indicate the remaining decay activity. In composting volatile soil tests indicate the same. In Vietnam the mineralisation of the organic material is measured by determining the protein and nitrate content. Measuring biological activity can also be done by determining CO₂ production. We were allowed to take a sample from one of the Vietnamese Toilets, which one week later in Bangkok was analysed by Dr Thanh of the Asian Institute of Technology. A part of the sample was dissolved in water and then the BOD₅ was determined to be 4364 mg/l. The rest of the sample was used in a volatile soil test and the residue content was found to be 10.5%. The Institute of Hygiene reported the following results:

TABLE 6

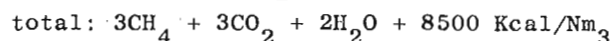
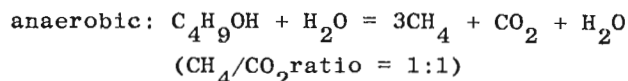
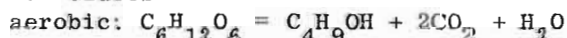
Proteins and nitrates in the compost

	Proteins gr/100gr	Nitrates gr/100gr
Before composting	1.102	0.011
After 4 hours	0.395	0.210
After 8 hours	0.020	0.446

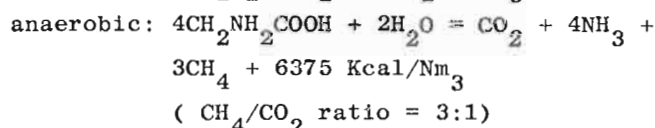
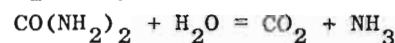
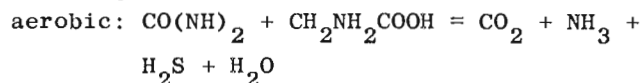
The nitrification is reportedly most effective during the fourth week of composting and a six week composting period is recommended in view of the agricultural use as a minimum period.

The Institute of Hygiene gives the following chemical processes to describe the composting in the Vietnamese Toilet.

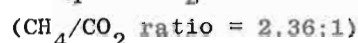
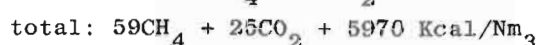
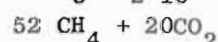
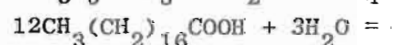
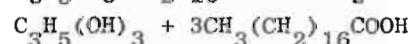
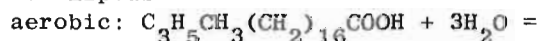
1. Glucose



2. Protein



3. Lipids

The implementation of the sanitation system

The Ministry of Health of Vietnam is through its Institute for Hygiene and Epidemiology responsible for the implementation of its rural sanitation system. The Institute works through its network of provincial stations and through the health centres of the Ministry of Health in the villages.

The sanitation programme was launched as part of a broader public health programme promoting the establishment of a protected well, a bathroom and improved latrine for each household. The programme has developed into one of the most successful public health efforts anywhere and deserves international attention. The health centres are well organised and work with careful planning methods. The health centre always has a map of the village with each house indicated and numbered. The number corresponds with the number of the health file of the family, which contains medical records as well as the environmental health conditions of the house and plot. The construction and condition of wells, bathrooms and toilets are carefully recorded here. A typical health centre is staffed by an assistant physician (medical assistant), a nurse, a midwife, a pharmacy assistant, two home visitors and two traditional medical practitioners. These health workers live in the village and are responsible for the development of the village public health programme. The plans are drafted at the district level and supervised from there.

The programmes include the construction of sanitary facilities, the cultivation and

processing of medical herbs for drugs, health education, family planning, preventive health care, inclusive vaccination programmes and curative outpatient services.

The district authorities train the health centre staff and provide them with information and propaganda material such as posters, demonstration models and leaflets. Much of the propaganda work is brought in the form of theatre performances. There are annual competitions between the health centres at the provincial and national level concerning performance and implementation of the public health programme. The health centre organises the population through its Red Cross Society which has a family health worker in each household¹⁷. It is a very finely developed mobilisation network which highly promotes the contact possibilities with the population. The family health workers receive regular health information and have some rudimentary health education. They act as family nurse and are trained to enlist more qualified health workers as soon as the problem cannot be safely handled by them. The family health worker sends all the family members to the centre for vaccination, constructs and maintains the well, bathroom and toilet and tends the family medical herb garden and holds the first aid box.

The Vietnamese public health system is based on a successful mobilisation of the population and on a careful definition of the roles which the various actors in the public health delivery system have to play from the national and provincial institutes to the family health worker. The very rapid implementation of the national health programmes testifies to the effectiveness of the Vietnamese public health system and its remarkable successes can serve as an instructive example to other countries.

The construction

The Vietnamese Toilet is in its present design and construction a low-cost solution. The toilet was developed as a part of the rural health work and the whole effort was therefore geared towards bringing sanitation within reach of the poorest peasants. In the villages there is no problem to site the toilet building, as is the case in the urban and suburban areas. The construction is therefore an independent building.

The construction material varies from place to place according to the local building tradition and the availability of materials. Most common are burned brick constructions with the floors made of concrete. Plastered adobe constructions are used in some areas, whereas even plastered bamboo constructions can be found.

Many areas in Vietnam have a very high ground water table and inundations are there very

common. It is in such areas necessary to build the whole toilet construction well above the surrounding ground. The floor of the vaults should be at least 20cm above ground level. The vaults measure 70cm by 70cm with a height of 60-70cm. There are therefore three or four steps leading up to the toilet door. The vaults each have a 25cm by 30cm opening to extract the compost located in the back or front wall. These are closed with bricks and mortar after emptying the vault. The vaults are not ventilated, since ashes deposited on the excreta sufficiently absorb odours. The slab over the two vaults forms the squatting plate and the floor of the toilet and has two openings with foot supports of which one has been sealed and the other has a lid. A urine drain in the slab leads to a tank. In many areas Health Centre workshops prefabricate and distribute latrine slabs.

To summarise, the advantages of the Vietnamese Toilet are simplicity, efficient pathogen destruction, good mineralisation of organic matter, safe use and handling, absence of odours and pollution, low costs, rich yield of fertiliser and applicability in flood-prone areas. The system can still be perfected, especially in its treatment of urine, but by and large all performance criteria for waste disposal systems are satisfied by it. The Vietnamese Toilet can be applied under difficult circumstances where other sanitation systems fail.

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