Human Faeces, Urine and Their Utilization

Translated by: Environmental Sanitation
Information Center Translation Committee, AIT

Published by:
Asian Institute of Technology
Library and Regional Documentation Center

P.O. Box 2754
Bangkok, Thailand

Available from:
Asian Institute of Technology
Library and Regional Documentation Center

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Environmental Sanitation
Information Center

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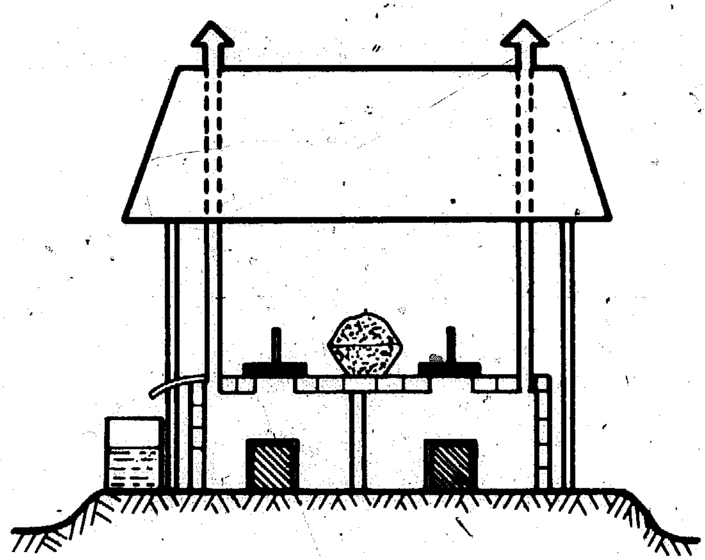

Translated from Vietnamese by

ENSIC Translation Committee

HUMAN FAECES, URINE AND THEIR UTILIZATION

From the Vietnamese book entitled "Phan Tieu, Nuoc Tieu va Cach Su Dung", authored by Viet Chy and published by "Nha Xuat Ban Nong Nghiep" (Agricultural Publishing House), Ho Chi Minh City, Vietnam, 1978.

English translation published by Environmental Sanitation Information Center, Asian Institute of Technology, P.O. Box 2754, Bangkok, Thailand.

Financially supported by International Development Research Centre, Canada; and Asian Institute of Technology.

SCRIPT/370 VERSION 3 processed at Regional Computer Center, Asian Institute of Technology.

Suggested Keyterms: COMPOSTING PRIVY / COMPOSTING PROCESS / EXCRETA / FERTILIZATION / NUTRIENT CONSERVATION / SANITATION / WASTE REUSE /

ISBN 974-8200-22-1

1981

HUMAN FAECES, URINE AND THEIR UTILIZATION

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by

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INTRODUCTION

This is a verbatim translation from the Vietnamese of the book "Phan Tieu, Nuoc Tieu Va Cach Su Dung". The translators have tried to convey the essence of the original, so that little has been done to produce a more polished publication.

We believe that the interest in this publication lies in the fact that this is a book meant to be read, and used as a "manual of practice" by Vietnamese farmers.

Though the book may seem to be a surprising mixture of scientific knowledge and practical advice, it is this very composition which makes the book of interest to non-Vietnamese readers.

ENSIC Translation Committee

VIETNAMESE PUBLISHER'S PREFACE

Human faeces and urine (excreta) are common fertilizers which have been used in several countries for many years. The methods of collection, processing and application of the excreta differ, depending on the level of scientific knowledge in each country. For many years Vietnamese farmers have used excreta as fertilizer to increase the yield of crops.

At present, in order to meet the planned target* of agricultural production (21 million tonnes of cereal, 4.8 million tonnes of vegetables and fruits) the demand for fertilizers, especially nitrogen fertilizer, is very high, while the amounts of inorganic fertilizers, either imported or locally produced, are limited.

However, if we can fully collect and utilize human faeces and urine as fertilizers, then the amount of nitrogen fertilizer in the excreta is many times greater than in locally produced or imported inorganic fertilizers.

This book "Human Faeces, Urine and Their Utilization" is based on the book "Phan Bac, Nuoc Giai va Cach Su Dung", written by Nguyen Hien and published in 1965. It has been completely revised and updated by Engineer Viet Chy. We sincerely recommend this book to all farmers; it is a book which can be studied, and the knowledge gained fruitfully applied.

The Publisher

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*Target of Five-Year Plan 1976-1980 (TRANSLATORS' NOTE).

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HUMAN FAECES, URINE AND THEIR UTILIZATION

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CROPS WITHOUT FERTILIZERS IMPOVERISH FARMERS

At the present time, there are no cooperatives or production units which manufacture fertilizers in excess of their own needs. Not only is the supply of fertilizers insufficient but the quality is also low. Poorly composted manure is used, thereby infecting the crops and endangering the health of animals and man.

The inadequate quantity and low quality of the fertilizers cause 1) low yields in all crops; 2) yields which are not constant but depend too much on Nature; 3) no feasible use of new varieties of crops with high quality and yields; 4) limited application of new agricultural machinery; 5) a low turnover rate of land use; 6) high-priced agricultural products and so on... Therefore, the state of poor agricultural practices continues. For crops to grow well, several conditions of light, temperature, air and nutrients have to be met. These needs are generally interchangeable, except for the nutrients which are not. Crops absorb nutrients from the soil and water, but the absorbed quantities are not always sufficient for a good yield. To improve the yield, additional nutrients must be supplied by the farmer in the form of organic or inorganic fertilizers.

Different crops require different quantities of nutrients, and even the same crops growing in different seasons, and in soils with different fertilities will require different quantities of nutrients. The demand for nutrients will also change as the crops grow. Therefore, the matter of fertilizing his crops with adequate nutrients requires careful consideration by the farmer.

Two types of fertilizers now available are organic and inorganic fertilizers (also called chemical or mineral and micro-organic fertilizers). For organic fertilizers, each variety has its own quantitative and qualitative properties. For example, considering the nutrient content, human faeces have higher nitrogen and phosphorus contents than buffalo dung or cow and pig manure, though their output is less than the latter.

Table 1 gives the quantities of nitrogen, phosphorus and potassium nutrients available in some commonly used fertilizers. From this table, it can be seen that human faeces contain 3 times more nitrogen nutrient (N-nutrient) than farmyard manure.

The amount of N-nutrient is highest in chemical fertilizers but at the present time Vietnam is not able to produce enough chemical fertilizers to meet its needs. Dry coconut oil cake and fermented fish cake also have high N-nutrient contents, but their availability is limited. Since crop yields are dependent on the amount of N-nutrients available to the crop during growth, the country's agricultural output is directly influenced by the supply of N-nutrient.

It can be said that, at present as well as in the long run, nitrogen fertilizer is and will be a deciding factor in the country's crop output.

Crops in our country seriously lack N-nutrient. Countries with advanced agriculture apply an average amount of 60 to 470 kg pure nitrogen per hectare, while in Vietnam, only 20 to 25 kg pure N-nutrient is applied in the North, and 8 to 14 kg pure N-nutrient is applied in the South. It can be seen that crops in Vietnam need N-nutrient.

Figures for the production and use of chemical fertilizers show that the quantity of fertilizer containing nitrogen is 1.5

Table 1: Quantities of Nitrogen, Phosphorus and Potassium Nutrients in some Fertilizers.

Fertilizer	Nitrogen kg/tonne	Phosphorus kg/tonne	Potassium kg/tonne
Farmyard Manure	1.62	1.59	3.105
Human Faeces	4.92	2.20	2.696
Human Urine	8.00	1.50	1.800
Waterfern *Azolla* sp.,	2.85	0.38	1.090
Crotalaria spp, leaves	6.53	0.55	2.200
Wood Ashes	-	60.0	150
Fermented Fish Cake	37.67	99.45	7.7
Coconut Oil Cake	36.7	6.30	4.9
Ammonium Sulphate	200.00	-	-
Urea	460.00	-	-

times greater than the quantity of fertilizers containing phosphorous or potassium. In 1974-1975, the world used about 82 million tonnes of N-nutrient fertilizer and the prediction for the year 2000 is 307 million tonnes (Appendix A Table 3).

NITROGEN - THE MOST IMPORTANT NUTRIENT

Table 2 shows the yield of some crops with respect to the application of the three main nutrients. From Table 2, it can be seen that in most cases, the N-nutrient gives the highest production yield for each kg of nutrient used. Therefore, agricultural economists and engineers are always trying to find ways to produce more N-nutrient fertilizers.

At present, the production of chemical fertilizers in Vietnam cannot meet the demand, and the import of chemical fertilizers from

Table 2 : Effects of Nutrient Application on Agricultural Outputs

Crops	Type of Product	Kg product increased/Kg pure nutrient		
		Nitrogen	Phosphate	Potassium
Rice	Grain	10 - 25	2 - 8	2 - 10
Wheat	"	10 - 20	10 - 12	4 - 40
Corn	"	20 - 25	6	3.8
Sweet Potato	Root	0 - 15	30 - 40	15 - 50
Potato	"	40 - 100	40	12 - 15
Peanut	Fruit	6 - 8	6 - 10	2 - 3.8
Soy Bean	Grain	7 - 8	1 - 4	2 - 3
Tea	Leaf	5 - 20	3 - 3.5	15 - 100
Tobacco	"	4 - 5	2 - 3	2 - 7
Cyperus sp.*	Stem	30 - 40	30 - 40	-
Sugar Cane	Stem	120 - 150	0 - 200	100 - 200
Cotton	Fiber and Seeds	5 - 7	0.8 - 1.6	4.12
White Mulberry (Morus alba)	Green Leaf	140	178	57
Sesbania, sp.	Green Parts	-	100 - 300	40 - 800
Azolla, sp.	"	-	100 - 150	40 - 70

* Group of aquatic plants grown to supply fiber for making handicrafts such as mats, handbags, etc. 3 species are cultivated : C. malaccensis Lam., C. tagetiformis Roxb and C. nutans Vahl.

other countries is limited. However, N-nutrient fertilizers can be made more available by increasing the cultivation area of leguminous plants, eg. soy beans, peanuts, mung beans, or plants giving green manure such as Crotalaria sp., Sesbania sp., Tephrosia sp., and Azolla sp., and by fully utilizing human faeces, urine, piggery washing water and municipal sewage as fertilizers.

Human faeces and urine have been recognized as good fertilizers, and several countries in the world utilize this source of nutrients. In Vietnam, if these sources of nutrients are fully collected, about 200,000 tonnes of N-nutrient, 50,000 tonnes of P-nutrient and 50,000 tonnes of K-nutrient could be obtained each year.

For N-nutrient alone, the quantity is equivalent to 400,000 tonnes of urea or 1 million tonnes of ammonium sulphate. In practice, however, it is difficult to collect all the faeces and urine, and an average collection of 70-80% of the available quantity is considered feasible.

Reliance on chemical sources alone for N-nutrient would not satisfy Vietnam's needs, but utilizing human faeces and urine, as additional sources of N-nutrient, would help the country to increase its agricultural output through intensive cultivation.

At the present time, the northern provinces in the delta area, compared to the provinces in the moderate level region, better utilize human faeces and urine, while, generally speaking, the southern provinces are wasteful of this source of nutrients. However, some localities such as Minh Tan and Ca Do in Quang Ngai province have collected and applied composted faeces to crops, though urine has not been fully utilized.

Though the beneficial effects of using composted faeces and urine as fertilizers on crops can be observed, yet many people are adverse to handling excrement, and believe that building a proper toilet would be costly. They also fear that the crops fertilized with human faeces and urine absorb unhygienic matter, and mistakenly believe that the crops directly absorb the unchanged excrement and urine on application. Harvested crops are only contaminated by excrement if faeces have been carelessly dropped on the leaves, or if the excreta are applied in the morning and the crops harvested in the afternoon on the same day. However, this is not the general practice. In the case of water spinach, the crop is harvested at least 10-15 days after application, while other crops are harvested at least one to two months after application.

HOW CROPS ABSORB NUTRIENTS

Crops need many nutrients such as nitrogen, phosphorus, potassium, calcium and magnesium for their growth and development. Crops absorb these elements from the soil, but usually in insufficient quantities, so that fertilizers need to be applied. In the early days of agriculture, man only knew how to use organic fertilizers such as animal manures, and later on green manures and excreta. Now science has advanced, and chemical fertilizers are manufactured to supply the necessary nutrients according to the type of soil, crop, season and stage of growth so that the final harvest is of good quality and high yield. Nowadays, a developed agricultural society utilizes both organic and chemical fertilizers.

The main nutrients for crops are nitrogen, phosphorous, potassium, calcium and magnesium. Crops also need other elements in lesser amounts which they normally obtain in sufficient quantities from the soil. These elements are called micro-elements and consist of sodium, iron, sulphur, boron, iodine, manganese, copper, zinc, cobalt and molybdenum, etc.

Crops obtain nutrients mainly through their roots and partly through their leaves. However, roots cannot directly absorb the organic matters from manures (faeces, urine and farmyard manures), and it is therefore necessary that these be first decomposed by the many species of micro-organisms present in the soil, urine and faeces. In other words, the organic matters in faeces and urine are biologically converted to inorganic compounds of nitrogen, phosphorous and potassium, similar to those found in chemical fertilizers, which can be readily absorbed by the roots. The process of decomposition of organic matters is called the mineralization cycle or biological path of the nourishment of crops. (In 1 gramme of good farmyard manure there are as many as 90 billion microorganisms and 1 gramme of soil contains 1 to 2 billion microorganisms).

Organic matter is a compound of carbon and other elements found in living things, animals and plants. Those in organic fertilizers and soils have their origins in animal manures, human faeces, rubbish, leaves, roots, dead animal remains and humus, etc. The process of mineralization is illustrated in Figure 1, in which the conversions are brought about by the microorganisms in the soils.

Taking urine as an example, this organic compound is available in human faeces and is synthesizable. When urea is applied to the soil, it is hydrolyzed by <u>Micrococcus urea</u> to ammonium carbonate and later to ammonia, carbon dioxide and water.

In other cases, hippuric acid in urine is hydrolysed by the

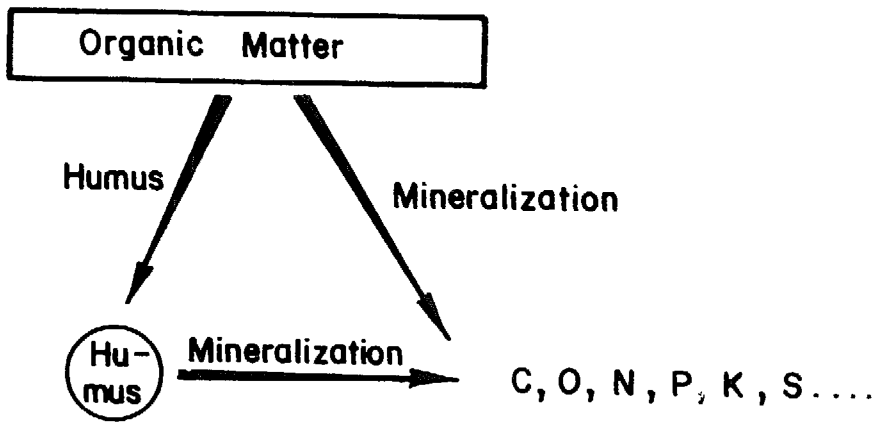

Fig. 1 Mineralization Process

action of the aerobic organisms to glycocoll (glycine) and benzoic acid.

Glycocoll is a nitrogen compound which is further hydrolysed to hydroxide acetic acid and ammonia.

Ammonia will combine with other acids to form ammonium ions and in this form it can be absorbed by the roots.

Not all chemical fertilizers can be immediately utilized by the crops on application. Some need to go through many conversions with many resulting intermediate substances, and the crops only absorb the elements and compounds they need. Take calcium cyanamide as an example. In the first stage, it reacts with water without the action of microorganisms as follows:

Calcium cyanamide + Water ⟶ Calcium Dicyanamide + Lime

Calcium dicyanamide will undergo further hydrolysis to give free dicyanamide which is very toxic to crops.

Within 10 to 15 days, dicyanamide reacts with water to form urea, which is then hydrolysed, as explained above, to give ammonia and then ammonium ion. It can also be oxidised to nitrite or nitrate. In these three later forms, N-nutrient can be absorbed by crops.

Therefore, it is necessary that nutrients be mineralized before they can be absorbed to satisfy the needs of crops.

Human excreta may contain particles of lipids, starches, chlorophylls, proteins, amino acids or other indigested foods. Amino acids will be decomposed by microorganisms such as Bacterium fuctrificus, Bacterium magatherium, etc. to organic acids or alcohol, and to ammonia with or without carbon dioxide. Depending on whether there are aerobic or anaerobic conditions, the biological reactions taking place are different. For example:

$$\underset{\text{amino acid}}{R\text{-}CHNH_2\text{-}COOH} + H_2O \longrightarrow \underset{\text{alcohol}}{R\text{-}CH_2OH} + CO_2 + NH_3$$

- In anaerobic conditions:

$$R\text{-}CHNH_2\text{-}COOH + 2H \longrightarrow R\text{-}CH_2\text{-}COOH + NH_3$$

- In aerobic conditions:

$$R\text{-}CHNH_2\text{-}COOH + O_2 \longrightarrow R\text{-}CH\text{-}COOH + NH_3 + CO_2$$

The ammonia produced will react with the acids which are available in the soil or which are secreted by the roots to form ammonium ions.

Other organic matters containing N, P, K, S also rely on micro- orgainsms for hydrolysis and converstion to inorganic forms such as N_2, NH_2, NH_3, NO_3, NO_2 etc. for nitrogen; PO_3, PO_4 etc. for phosphorous and H_2S, SO_4, S_2 etc. for sulphur. These inorganic compounds will then be selectively absorbed according to the crops' requirements.

To summarize, when applied to crops, faeces and urine have to undergo the mineralization process before they are absorbed by the crops.

HOW UTILIZATION OF HUMAN FAECES AND URINE HELPS TO CONTRIBUTE TO A CIVILIZED LIFE, A CLEAN VILLAGE AND FERTILE FIELD

Though Vietnam is seriously deficient in N-nutrient to provide for its crops, there are plentiful sources of nutrients in human faeces and urine. However, in a civilized society, it is unacceptable to defecate carelessly and randomly in fields, whether they are in the city or countryside. Besides being socially unacceptable, defecating in fields leads to infectious diseases such as dysentery, poliomyelitis, typhoid, diarrhoea, cholera and other parasitic diseases. For example, if a man who has tapeworm (Taenia) defecates in a field and pigs feed on his faeces, then Taenia larvae can develop in the pigs' flesh, and when this pork is eaten the consumer is likely to get Taenia whereas if the man defecates in septic bins, the chance of Taenia infestation in eliminated.

In the North, almost all families in the delta provinces have their own septic bins; in the moderate level regions, a majority of families have septic bins; and in the mountainous regions, many villages and cooperatives have built hygienic septic bins and collected human excreta for fertilizer. In the South, during the War of Resistance against France and the United States, a number of villages used septic bins to collect excreta, and ashes baskets to absorb urine for their crops.

Table 3 gives the chemical composition of human faeces and urine as a percentage of wet weight.

The percentage of nutrients in fresh faeces and urine varies, depending on the age, activity and nourishment of the person; the same is true for the daily quantity discharged. Data showing the quantity of nutrients in the faeces and urine discharged by an average adult per year are shown in Table 4.

Research carried out by a vocational school showed that a man in a moderate level region discharges about 60 kg excreta and 300 kg urine per year. In Japan, the figures are 72 kg excreta for an adult and 26.5 kg excreta for a child. In China, it is 42.5 kg excreta per capita. Data comparing the daily amounts of faeces and urine discharged by men, women and children are given in Table 5.

Table 3: Chemical Compositions of Human Faeces and Urine as a Percentage of Wet Weight.

Constituents	Urine	Faeces	Mixture (excreta)
Water	94.8	77.2%	93%
Dry matters	5.2	22.8	7.0
Organic matters	4.2	18.4	5.7
Ashes	1.0	3.4	1.3
N-nutrient (as nitrogen)	1.0	1.6	1.1
P-nutrient (as P_2O_5)	0.15	1.23	0.26
K-nutrient (as K_2O)	0.18	0.55	0.22

Table 4: Quantity of Nutrients in the Faeces and Urine Discharge by an Average Adult in kg/year.

Constituents	Urine	Faeces	Total
Total weight	438	48.5	486.5
Dry matter	23.0	11.0	34.0
Organic matter	18.2	9.4	27.6
N-nutrient (N)	4.4	0.8	5.2
P-nutrient (P_2O_5)	0.66	0.6	1.26
K-nutrient (K_2O)	0.81	0.27	1.08
Lime (CaO)	0.08	0.29	0.37

Table 5: Daily Amounts of Faeces and Urine Discharged by Men, Women and Children.

	Faeces			Urine		
	Total (g)	N	P	Total (1)	N	P
Adult, male	150	1.74	3.23	1.50	15.0	6.68
female	45	1.04	1.08	1.35	10.7	5.40
Children, male	00	1.84	1.60	0.57	4.72	3.46
female	25	0.57	0.73	0.35	3.68	1.75

Generally speaking, men produce greater amounts of faeces and urine than women and the quantity of nutrients in adult faeces is greater than in the faeces of children. The contents of N-nutrient and P-nutrient in male faeces are lower than those in female faeces, but the contents of N- and P-nutrients are higher in male urine than in female urine.

An adult discharges a daily average of 130-140 g of faeces, comprised of 25 g of dry matter, 4.5 g of ashes, 2 g of N-nutrient, 1.4 g of P-nutrient and 0.6 g of K-nutrient. A family of 4-5 members can collect, in a month, 16-20 kg excreta, or 180-220 kg per year, in which there are 3 kg N-nutrient, 2 kg P-nutrient and 0.8 kg K-nutrient. These amounts are equivalent to 15 kg ammonium sulphate or 6 kg urea, 10 kg super phosphate and 1.6 kg potassium (excluding fillers).

An adult also discharges about 1.5 l urine per day. If urinals are built in public places, then the quantity of urine collected may be even higher. A conservative estimate of the volume collected at home is 200 to 300 l per capita per year. Thus each family can collect nearly 1 tonne of urine, in which there are approximately 10 kg N-nutrient, 1.2 kg P-nutrient and 1.6 kg K-nutrient. These amounts are equivalent to 20 kg urea, 6 kg super phosphate and 3.2

kg potassium sulphate.

If the above estimated quantities of human faeces and urine are applied to a field of rice, maize or potato, and calculating for the N-nutrient alone, a family may gain 130 to 150 kg extra crop yield. This fact clearly indicates that the utilization of human faeces and urine contributes to fertile fields and a clean village. However, a change from a state of ignorance about the value of faeces and urine to the habit of utilizing them is not easy to make. It has been observed that in regions where people are not in the habit of using septic bins, to persuade a family to build one is a very difficult task. After building the septic bins, to persuade them to use it and keep it clean is not easy. Above all, it is most difficult to persuade people to empty the bin and to carry the compost to the fields.

THE HYGIENIC SEPTIC BIN

It would be clean and hygienic if in the countryside cesspools* could be built like those in the cities. However, many villages do not have the means to build such public toilets, and the villagers themselves are therefore dependent on their own means to build suitable septic bins. The septic bin can be built of earth or brick, or of half earth half brick, but in all cases it must meet the following technical requirements:

Floor

The floor of the faeces tank must be hard, so that faeces cannot percolate out and water cannot permeate into it. To meet this requirement, the floor can either be cemented, or made of brick, or of a compacted mixture of lime and sand.

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* The term in Vietnamese is not clear. It may also indicate vaults or septic tanks (TRANSLATORS' NOTE).

Faeces Compartment

The faeces compartment must be closed to keep out mice, flies, chickens and dogs, and to prevent the excreta from spreading and causing an unpleasant smell. The hole for defecation must always be closed after each use. The faeces compartment is usually built on ground with a thick wall of brick or compacted earth. On the back wall of the compartment, there must be a door large enough for collecting the composted faeces with a spade or a hoe. This door must always be kept closed with a wooden cover or brick. All other openings are closed with mud.

Roof

The toilet must be roofed to keep out the sunshine and especially the rain. If the faeces are wet, the microorganisms are able to anaerobically, decompose the organic matter containing nitrogen, and since the new compounds, especially indol and scatol, are not yet completely mineralized, this causes the toilet to have an unpleasant smell. The roof also helps to keep the rain from wetting and washing away the excreta into ponds and public wells which cause the spread of diarrhoea, dysentery and other parasitic diseases.

The type of toilet developed and recommended by the Ministries of Agriculture and Public Health is the double septic bin. It is low-cost and easy to build, and the accumulated faeces can be removed for use as fertilizer.

THE DOUBLE SEPTIC BIN : LOW-COST AND EASY TO BUILD.

Every family of 4 to 5 should build a double septic bin (DSB), set down-wind and far from the house.

The main part of the DSB is the above-ground-level faeces tank, 1.8 to 2 m long, 0.9 to 1 m wide and about 0.8 m high. Where it often floods a high foundation should be made for the tank. The faeces tank is divided equally into 2 compartments. On the top of each compartment there is a hole which is large enough so that when in use the stools do not touch the edge of the hole while falling down. A lid with a handle should be made for each hole. In front of each hole two blocks of brick are placed at a suitable position. (Fig. 2a, c). A groove for urine drainage is also made (Fig. 2a, b, c).

The reason for building a DSB is its capability to compost the faeces without having to remove them when they are still fresh and dirty. When the first compartment is full, it is tightly closed and the second compartment used. By the time the second compartment is nearly full, the faeces in the first compartment have been composted for 2 to 3 months, the period necessary to have well-composted faeces ready for use. The compost in the first compartment is then removed and the second compartment closed with mud. The first compartment is now used again.

Urine must be collected separately and must not be allowed to run into the faeces tank. Rain water must not permeate into the faeces tank since the faeces will decompose in anaerobic conditions causing an unpleasant smell.

A brick DSB will require the following materials: 240 bricks (for faeces tank), 20x10x5 cm; 20 kg lime; 3 kg cement; and an additional 550-600 bricks, if the walls are constructed of bricks.

In some toilets, a vent is also provided to keep them free from malodour (Fig. 4).

PROCEDURES FOR THE HYGIENIC USE OF A SEPTIC BIN

A family of 7 to 8, or more persons, should build a 3-compartment septic bin since the time required to fill a faeces compartment will be shorter. Building a 3-compartment septic bin will allow the faeces to be composted for a longer time than in a DSB. Only well composted faeces are suitable for use as fertilizer. In the countryside, every family can collect kitchen ashes and store them in a dry place to be used as filler. Normally a mixture of one portion in weight of ashes, one to two portions of dry soil powder, and 2 to 5% of super phosphate is used as filler for the septic bin. The filler mixture is stored in a small basket or box inside the toilet, and a small spade or scoop provided for spreading the filler on the faeces after defecation. Spreading filler on the faeces keeps them dry and prevents flies and maggots from developing. After defecation, the hole is closed with a lid to keep out chickens, dogs and mice.

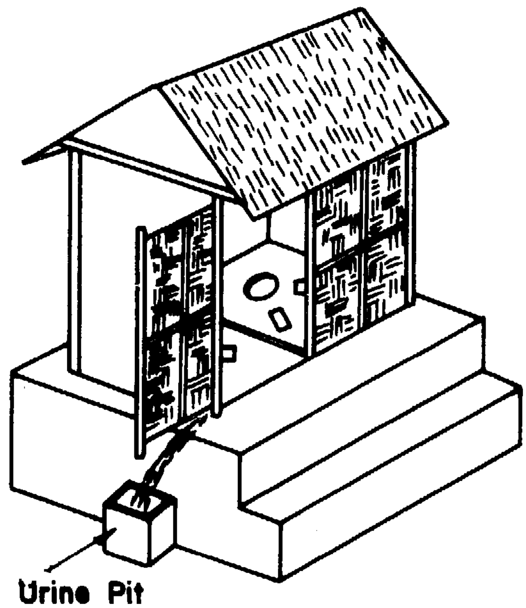

Fig. 2 a Earthen Double Septic Bin
(Isometric View, Front Side)

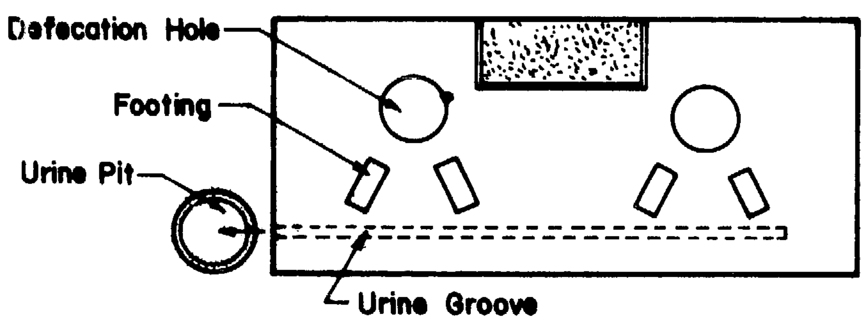

Fig. 2 b Plan View of Double Septic Bin

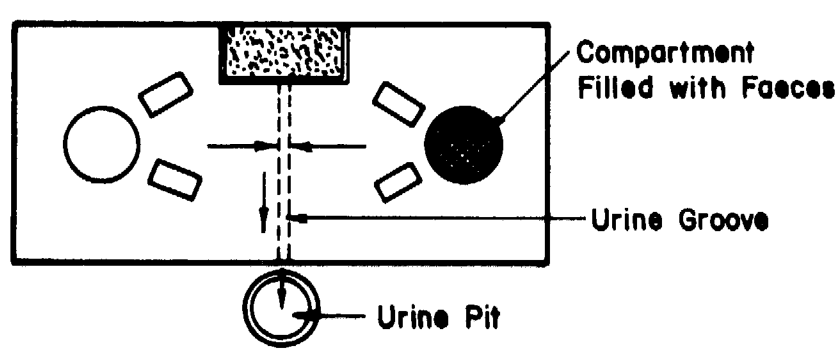

Fig. 2 c Alternative Arrangement, Plan
View of Double Septic Bin

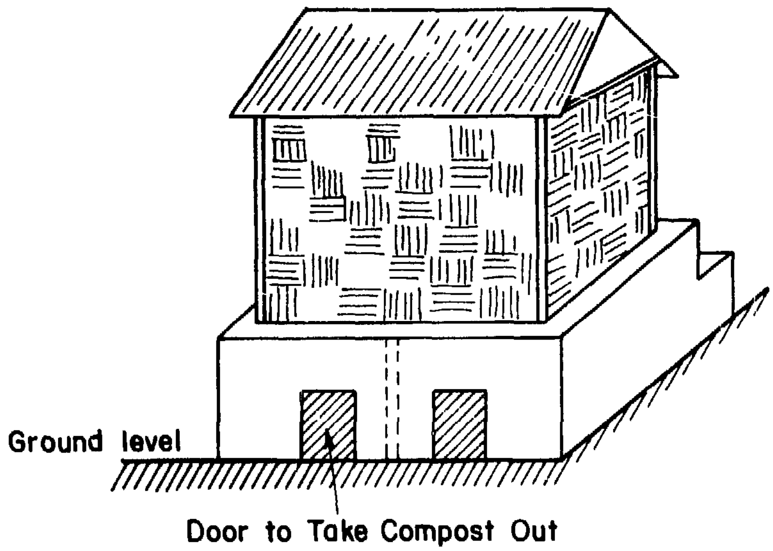

Fig.2d Isometric View, Back Side of Double Septic Bin

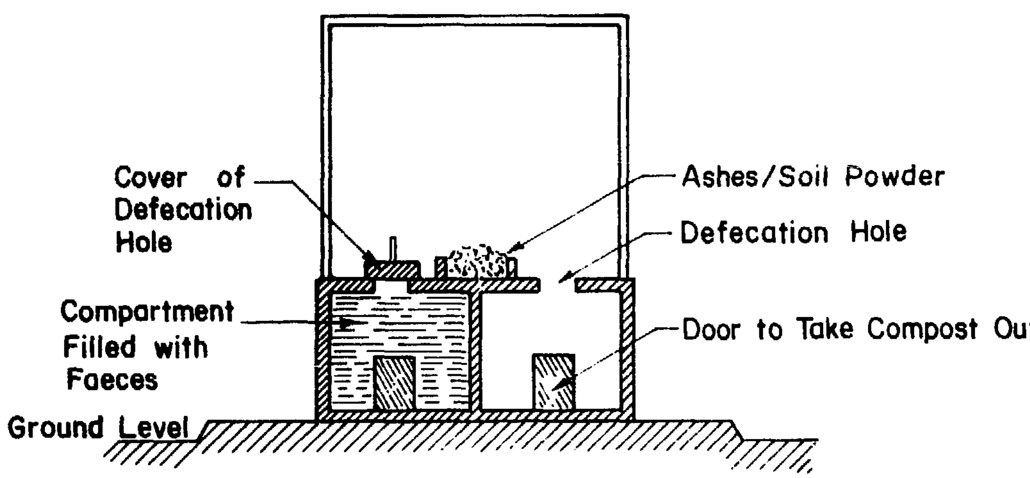

Fig. 2e Cross Section of Double Septic Bin

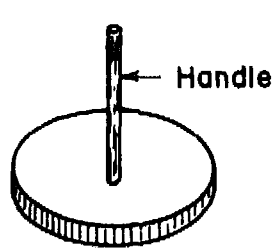

Fig. 3 Wooden Cover for Defecation Hole

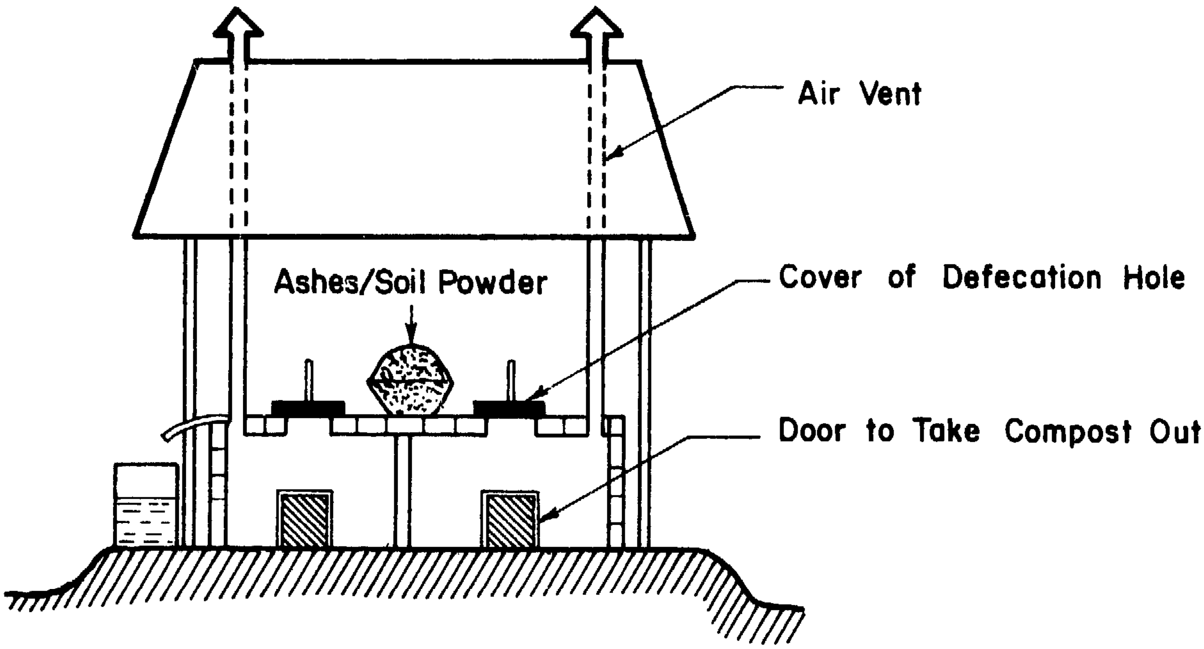

Fig. 4 Double Septic Bin with Air Vents

If the faeces inside the compartment are wet, sawdust, dry rice husk or rice straw cut into small pieces must be added. Where peat or humus leaves are available, these should be collected, dried and used as filler. When the faeces compartment is full, a thick layer of hot ashes, and then a thin layer of dried soil powder is spread on the top. The hole is covered with its lid and sealed with mud. The second compartment is then used for defecation.

In the summer or in the rainy season, if there are many flies and maggots in the compartment, pesticides such as BHC and DDT can be directly applied to the faeces, or to the walls of the toilet and the faeces can be sprayed with "Vofatox", cresol or BHC. Adding 2 to 5% super phosphate and dried soil powder to the faeces increases the composting rate, kills enteric bacteria, and reduces the loss of N-nutrient during the fermentation and composting period.

Experiments have shown that if dried soil powder is used as a

A tin cask with a handle is placed down into the faeces tank filler, it reduces the amount of N-nutrient lost during the 3-month composting period by 17 to 20 times, in comparison with when the tank is filled with ashes alone.

COMMUNAL LATRINES

In public places, the number of tanks to build to a latrine depends on the number of people using it. The daily amount of faeces collected is large and thus composting within the tank is impossible. Therefore, the type of latrine from which the faeces can be removed each day to be composted at other places should be built (Fig. 5). The work must be organized so that everyday there is a man responsible for cleaning the latrine and removing the faeces. Users also have to be educated to keep the latrine clean by defecating through the hole provided in the faeces tank, to spread soil powder or ashes onto the faeces and to close the hole with its lid after use.

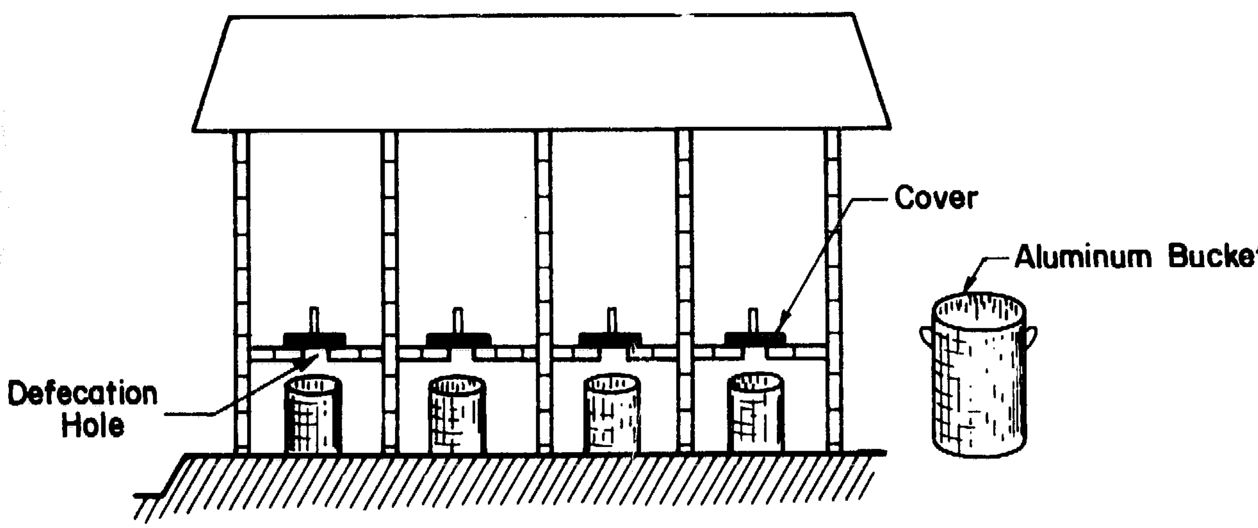

Fig. 5 Communal Toilet

through the defecating hole to collect the faeces. The cask is replaced daily and the faeces taken to the processing house for composting. The cask must be correctly placed within the tank to prevent faeces dropping out of the cask, and a layer of ashes or soil powder spread on the bottom of the cask to facilitate the later removal of the faeces.

The processing house, where the faeces are composted, must have a hard floor, roof and surrounding walls. The faeces are collected in a pile so that between every 15 to 20 cm layer of faeces there is a layer of chopped rice stubble or dried peat. The whole pile of 1.5 m high is then covered with super phosphate or apatite powder to prevent the loss of N-nutrient by evaporation, and also to keep flies from breeding.

The man who works in the processing house must wear high boots and plastic gloves, and must remove the faeces out of the cask with a spade or hoe. At the end of a day's work, he must carefully wash his hands, feet and face with soap.

HOW TO COMPOST HUMAN FAECES TO PREVENT A LARGE LOSS OF N-NUTRIENT

A serious problem that faces all agricultural scientists when investigating the production of organic fertilizers is how to prevent a large loss of N-nutrient from the fertilizer products. Human faeces contain not only species of microorganism which catalyse the formation of ammonia, but also many other species which contribute to the process of decomposition of the organic matters containing nitrogen. Included in the latter species are <u>Nitrosomonas</u> and <u>Nitrobacter</u> which bring about the nitrification process by converting NH_3 to NO_2 and NO_3 . Other microorganisms such as <u>Bacterium denitrificans</u>, <u>Pseudomonas fluorescens</u> bring about the nitrification process in anaerobic conditions by reducing NO_3 to NO_2. Nitrogen gas then evaporates from the faeces pile, with the result that N-nutrient is lost.

In addition, rain also causes the loss of N-nutrient, since rain water washes the faeces away or helps them to percolate into the soil. Therefore, it is always recommended that the toilets be built with a roof, four walls and a hard floor.

Procedures for composting the faeces to prevent a large loss of N-nutrient are given in the following paragraphs:

As mentioned above, reactions brought about by microorganisms take place during the collection and accumulation of human faeces. Therefore in a family or public toilet, it is necessary to spread soil powder, dry kitchen ashes, and 2 to 5% super phosphate or apatite powder on the faeces in order to keep them dry, and to absorb the N-nutrients which can be lost by evaporation or by leaching. Dried leaves, for example, can absorb water 300 to 475 times its initial weight; rice stubble can absorb water 400 times its initial weight, and peat can absorb water 400 to 600 times its initial weight. With such high water absorption capacities, these fillers can help to conserve the N-nutrient present in water. In considering the capacity of some common fillers to absorb evaporating N-nutrient, it is observed that 1 kg peat can absorb 35 to 40 g N-nutrient, 1 kg super phosphate when composted together with farmyard manure can absorb 80 g N-nutrient, 1 kg rice or cereal stubble can absorb 8 to 10 g N-nutrient, 1 kg leaves from the pea family can absorb 15 to 25 g N-nutrient, and 1 kg dried leaves can absorb 25 to 46 g N-nutrient. The N-nutrient absorbed is in the form of ammonia. Dry soil powder, like rice straw, stubble and peat, besides having a capacity to absorb water 2 to 3 times its initial weight, is also a very good NH_3 absorber.

Dry soil powder has very fine particles called "soil gel", whose diameters vary from one-thousandth to one-millionth mm. One of the significant properties of soil gel is its capacity to absorb ions such as NH_4, K, etc. The finer the soil powder, the more it can absorb ions. Experiments with silica gel show that 1 kg coarse silica gel can absorb 1.55 g NH_4 and 0.7 g K, 1 kg medium-size silica gel can absorb 5.68 g NH_4 and 3.14 g K, and 1 kg very fine silica gel can absorb up to 7.92 g NH_4 and 5.77 g K.

Farmers who used dried soil powder as the filler in the process of accumulating and composting the faeces observed that the compost had better fertility. This is because dried soil powder, as well as peat and super phosphate, is able to prevent the loss of N-nutrient. In many countries it is illegal to apply fresh excreta, mixed with water, to the crops because there are many inherent dangers in this practice, for example, the accumulation and spreading of pathogenic germs and parasitic eggs to animals and humans. The fertility of the excreta is also wasted if it is applied in this way. Experiments have shown that with the same amounts of faeces, the composted faeces help to increase crop yields by 20-25%, as compared with fresh faeces.

The application of fresh excreta induces a mesophilic composting process, in which the temperature in the faeces pile or pit is low, and intestinal viruses and bacteria which cause diarrhoea, cholera and dysentery, and parasitic eggs such as Taenia and Ascaris, are not eliminated With human faeces it is preferable to use the thermophilic composting process in which the temperature of the faeces pile rises to 50 or 60°C . The temperature lasts for some time before there is a gradual reduction. Experiments carried out by sanitary enterprises and the Institute of Hygiene and Epidemiology have demonstrated that the thermophilic composting process is able to accelerate the inactivation of bacteria and parasites.

THERMOPHILIC COMPOSTING

Sanitary state enterprises and cooperatives should use thermophilic composting to process the faeces from public sources. The processing house should have a floor of brick, cement, or compacted earth on which to spread a layer of rice stubble, grass hay or peat about 30 cm thick. On this layer, faeces and filler are alternatively spread in thicknesses of 10 cm and 20 cm, respectively. When the pile is 1.2 to 1.5 m high it is covered and surrounded with rice stubble or dried grass and finally daubed with a layer of mud about 5 to 7 cm thick. Super phosphate or apatite powder may also be added in layers of 1 to 2 cm thick to the top layers of the pile (Fig. 6).

In the thermophilic composting process, the pile turns black by the 7th day (or by the 10th day in cold winters), and the temperature continues to rise for 15 to 20 days. If the pile is too dry, it should be sprinkled with some water or urine to enhance the activities of the microorganisms.

If the quantity of excreta is insufficient and farmyard manure is available, the two can be composted together. Use 10 parts of farmyard manure to 1 to 2 parts of human excreta. This increases the fertility of farmyard manure and the compost should then be used on crops with high market value, such as vegetables, potatoes and beans.

In the thermophilic composting method, faeces are ready for use in 1 to 2 months. In some places, human faeces are still being

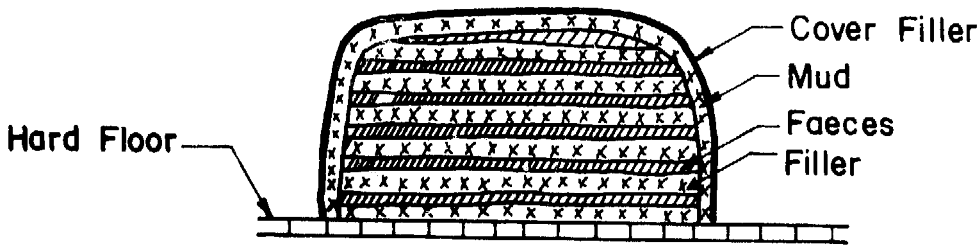

Fig.6 Compost Heap

collected for composting in the open, in a corner of the yard or walkway. This is not only unhygienic but also inefficient. In such cases, the faeces should be composted in an underground pit. The pit should be built of brick, but where this is not possible, the floor and sides must be strongly compacted. Human excreta and fillers are placed into the pit as in the case of composting in the processing house. When the pit is full, it should be covered to keep out the rain (Fig. 7). The pit dimensions depend on the quantity of faeces to be composted.

ON-SITE COMPOSTING

This is the case for a family DSB where only one compartment is used at a time. In the toilet there must always be a basket of ashes or a mixture of dried soil powder and ashes. If possible, 2 to 5% super phosphate or apatite powder should be added to the mixture. After each defecation, some filler (ashes or dried soil powder) is spread on the faeces and the hole closed with a lid. When the faeces compartment is almost full, the faeces are flattened with a stick, and the compartment used until it is almost full again. A layer of filler about 10 cm thick is then spread on the top, the hole tightly closed, and the lid daubed with mud. Before spreading the layer of filler on the top the faeces should be stirred with a stick. This helps to improve the composting condition as the temperature increases rapidly, thus eliminating

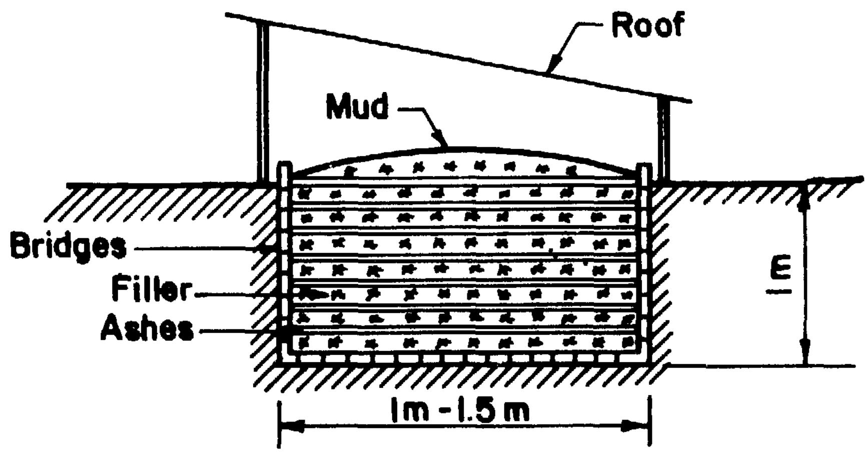

Fig.7 Underground Composting Pit

intestinal bacteria and parasites.

Research data have shown that if human faeces are composted alone for 3 months, only 36% of N-nutrient is left; if the faeces are composted with ashes, the results are even worse as only 15% N-nutrient is left; but if soil powder is used, 95% N-nutrient is left after composting for the same period of time. This clearly indicates that fillers of dry soil powders, leaves or rubbish are best used for composting. However, not all families can prepare a sufficient quantity of soil powder, leaves or rubbish, whereas kitchen ashes are always available. Filling with ashes alone results in a large loss of N-nutrient, and therefore it is more advantageous to use a mixture of ashes and soil powder as a filler. The hot ashes absorb water and kill germs while the soil powders absorb the evaporating N-nutrient.

To have a good compost the full compartment must be kept tightly closed for a period of 30 to 40 days. During this time the second compartment is used for defecation. Sometimes it is necessary to remove faeces from the composting compartment, but if there is no urgent need for this, faeces can be piled up, compacted and daubed with mud at a place away from disturbance by animals. The pile is then covered with dried leaves, stubble or rubbish to protect it from the rain and sun.

CLOSED (MESOPHILIC) COMPOSTING

In cities and towns with large populations, the daily quantity of excreta produced is very high. In these cases, it is best to have contracts with sanitary state enterprises to daily transport and distribute the collected faeces to cooperatives in the outskirts of the towns for processing. It is also possible to contract with the sanitary state enterprises to build and operate faeces processing plants to ensure that hygienic conditions are met, and to distribute the compost to cooperatives and other users.

With large daily quantities of faeces, the thermophilic composting method as described in Section "THERMOPHILIC COMPOSTING" is not suitable, because of an inadequate quantity of fillers, except in areas where peat and sea mud are available.

In the thermophilic composting method, although the faeces pile is daubed with mud, the fillers, rice stubble and rubbish are so voluminous that the pile is clumsy and porous and contains a large volume of air which enhances the activity of aerobic microorganisms.

In the closed composting method, a series of houses with roofs and deep floors are constructed. The floor is divided into many compartments. The composting time is longer than in the thermophilic composting method, and experiences have shown that in cold winters even longer composting times are required before the excreta is well composted for use. If the excreta must be quickly decomposed at an ambient temperature of 20° C, some soybean leaves should be placed in the excreta. Quick fermentation is now possible since on the soybean leaves there are some kinds of yeasts which can readily decompose and ferment the organic matters in human faeces. Soybean shells and cakes can also be used instead of soybean leaves.

The main fillers which are used are soil powders and dried alluvium, with 1 part of faeces mixed with 1 to 2 parts of fillers. On every layer of faeces a thin layer of lime and BHC is spread, and finally on the top layer of faeces a layer of soil powder about 5 to 10 cm thick.

In this composting process, the temperature within the faeces pile quickly increases at the beginning and then it reduces.

Normally the temperature is not high and it cannot be maintained for as long as in the thermophilic composting process, and therefore lime, super phosphate and BHC must be added to eliminate intestinal bacteria and parasites. Experimental results show that for best results, 1 part of excreta should be mixed with 3 to 5 parts of soil powder. Tobacco farmers use an even higher ratio of soil powders to excreta to have a larger volume of compost for preplant application. However, composting with a large volume of soil powder requires much time, and 1 to 2 parts soil powder to 1 part excreta seem to be a reasonable mixture to use. The resulting compost normally contains 1.3% N-nutrient and 2% P-nutrient. Where peat and leaf humus are available, they should be used for thermophilic composting. (The pH of peat and leaf humus is usually low, and the N-nutrient in peat is between 2.3 to 3%, but it is in a form which is not available for crops. When used as a filler in composting, peat helps to eliminate any undesirable bacteria and parasitic eggs, and in return the faeces help to convert the N-compounds in peat to simple forms which can be absorbed by crops).

In many European countries, peat is used as a filler for composting urine, farmyard washing water and human faeces. For every tonne of dried peat, 0.5 to 2 tonnes of urine are applied and the pile is left for 4 to 5 days to ferment. Another tonne of dried peat is then added to the first pile and urine applied. The process continues until the pile is about 1.5 to 2 m high. Sometimes human faeces are also added to the pile to increase the fertility of the compost.

If peat and human faeces are composted together, the ratios given in Table 6 are recommended. Generally speaking, the amount of peat needed is less when its moisture content is high.

The amounts of this kind of compost which can be applied to different crops are 10-15 tonnes/ha for fruit crops, 15-30 tonnes/ha for root crops, 20-40 tonnes/ha for leaf crops and grains used as animal feed, and 5 tonnes/ha for vegetable crops.

The fertility of composted peat is greatly improved by the addition of human faeces. Using 20 tonnes of a compost of human faeces and peat for potatoes gives an additional harvest of 12 tonnes/ha as compared with using a compost of 50 tonnes of peat alone. In mountainous or semi-mountainous regions where wild tree leaves are plentiful, they should be collected, chopped into small

Table 6: Recommended Ratios of Human Faeces and Peat to be Composted Together.

Category	Moisture Content of Peat			
	Very dry	30%	40%	50%
Moss peat	1:9	1:6.3	1:5.4	1:4.5
Weed peat	1:3	1:2.1	1:1.8	1:1.5

pieces, dried and used as filler for composting human faeces. This filler helps to prevent a loss of N-nutrient during the composting period.

Table 7 gives the nutrients available in a compost of human faeces and dried leaves. A ratio of 3:1 of faeces to leaves is best as it increases the quality of the compost and reduces the amount of leaves required. Agricultural cooperatives which receive the faeces for composting should be organized so that there is a team responsible for receiving, composting and distributing the compost to other productive teams. This team should be well equipped with tools and protective clothing. The cooperatives must also have proper composting houses which are located far from dwellings and public wells, at places convenient for receiving the faeces and distributing the compost. It is also worthwhile to hold meetings between the sanitary state enterprises, government agricultural offices and cooperatives to discuss the costs for distributing the faeces, the methods of processing, and the crops to be cultivated for the best harvest.

DRIED FAECES POWDER

The practice of digging pit latrines without roofs and hard floors in fields or along walkways should be discontinued since it is unhygienic and wasteful of N-nutrients.

Table 7: Nutrients in a Compost of Human Faeces and Dried Leaves.

Ratio of Faeces to Leaves	Moisture %	N-nutrient %	P-nutrient %	K-nutrient %
4:1	68.8	0.896	0.454	0.736
3:1	75.3	1.860	0.699	0.342

Dried faeces powder is produced in many countries where it is illegal to apply fresh human faeces to crops whose leaves and fruits are eaten fresh. Fresh faeces are collected in the cities and towns and transported to a processing plant which is usually located in a suburban area. There the faeces are disinfected with chlorine, sun-dried, or oven-dried, and made into a powder. This powder usually contains 8% N-nutrient (N), 4% P-nutrient (P_2O_5), 1.5% K-nutrient (K_2O) and 19% chlorides. The moisture content of the powder is about 12%. The dried faeces powder fertilizer has a quick and strong effect on crops. It is usual to apply 0.6 to 1.2 tonnes for every hectare several days before cultivation.

Vietnam has not yet produced any dried faeces powder fertilizer but it is worthwhile to consider and investigate its production. Such fertilizers can be guaranteed for hygiene and quality if they are produced by plants which are managed by collectives and supervised by the government.

EFFLUENTS FROM VAULTS

In large cities, vaults are used in great numbers. Water is used to flush the excreta to a deep tank and when this is full the effluent mixture of water, urine and excreta is removed by tank truck or cart. The effluent usually contains 90% water, 0.8% total nitrogen, 0.4% ammoniacal nitrogen, 0.4% phosphate, 0.1% potassium, 0.18% calcium, 0.09% magnesium and 0.45% chlorides. The effluent should be composted with rubbish, peat, leaf humus, dry soil powder and 2 to 5% super phosphate or apatite powder; some lime and BHC should also be added. The effluent should not be directly applied to any leaf vegetables. It can be used for basal application to other crops: after ploughing, 10 to 30 tonnes per hectare can be applied, covered, and allowed to compost for 15 to 20 days before cultivation. If the effluent is used for fertilization, it should be diluted 3 to 4 times with water as the undiluted one may cause the crops to die from urea poisoning; 4 to 5 tonnes per hectare can be applied.

If the cooperatives do not properly process the supplied excreta, the sanitary state enterprises should not distribute the excreta to them. The dangers to public health of misapplying the excreta should also be explained.

PRECAUTIONS TO TAKE WHEN COMPOSTING AND APPLYING HUMAN FAECES

Even though crops may be deficient in N-nutrient, it is not acceptable to use human faeces imprudently and to continue applying excreta improperly. Human faeces must be carefully used so that infectious diseases are not spread. Therefore:

Management and Distribution

The management and distribution of human faeces in cities, towns and districts must be undertaken by sanitary state enterprises or agricultural offices. The collected faeces should be transported out of the cities in special and hygienic tank trucks, and unnecessary movement of the trucks should be avoided within the cities. Faeces should not be distributed to individuals who carry them in baskets on bicycles, since the faeces may spill out onto the streets or walkways during transportation.

Faeces must not be distributed to places where there is no proper processing house or special teams who are responsible for the processing and equipped with suitable tools.

Pathogen Destruction

During composting and processing of the faeces, parasites (such as Ascaris, hookworm and Trichuris) and pathogenic viruses and bacteria which cause dysentery (Shigella), typhoid (Salmonella typhi) and acute diarrhoea in children and young animals (rotavirus, E. coli, Shigella, Salmonella and other species) must be eliminated.

Temperature

The higher temperatures can be met by the thermophilic composting method in which the faeces pile is porous (due to the voluminous filler) and daubed with mud. In the thermophilic composting, method the temperature of the faeces pile will reach 65 to 70°C after 4 to 5 days in summer, and 9 to 10 days in winter. The pile will maintain this temperature for 7 to 15 days depending on the size of the pile. The pile must be daubed with mud to ensure that within the 7 to 15 days the parasitic eggs and bacteria in the center of the pile and on the outer layer are killed. In the closed or mesophilic composting method, the temperature of the pile slowly rises and the maximum temperature reached is not as high. Therefore, lime, super phosphate or apatite powder and BHC must be added. After 1 1/2 to 2 months the pile is turned over, and one more month is needed before the faeces are well composted and the parasites and bacteria eliminated.

Nutrient Conservation

Attention must also be given to the quality of the compost i.e. the amount of N-nutrient lost must not be high. To meet this requirement :

a) the composting house must be roofed and have a hard floor,
b) the faeces must be mixed with fillers such as soil powder, super phosphate or apatite powder; and
c) the faeces pile must be tightly daubed with mud.

URINE

Assuming that the average man produces 300 kg urine per year, then 15 million tonnes of urine can be collected every year, an amount as much as half of the total animal manure now collected. The N-nutrient, P-nutrient and K-nutrient are all in simple forms that can be quickly hydrolysed by ammonifying bacteria (eg. Micrococcus urea) uric acid and urea in the urine are converted to NH_3, CO_2 and water. For example, uric acid is hydrolysed to urea, with enzyme urease as the catalyst, acccording to the following reaction:

$$\underset{\text{uric acid}}{C_5N_4O_3H_4} + 4H_2O \longrightarrow \underset{\text{urea}}{2CO(NH_2)2} + \underset{\text{tartronic acid}}{\text{COOH-CHOH-COOH}}$$

Urea is then ammonified to ammonia gas, which causes the characteristic smell around urine tanks. Since urine contains about 1% nitrogen, about 150,000 tonnes pure N-nutrient can be obtained from 15 million tonnes of urine per year. This is equivalent to 750,000 tonnes of ammonium sulphate, or as much as half of the national production of nitrogen chemical fertilizer. In other words, the amount of N-nutrient is equal to the output of 7 moderately-sized nitrogen fertilizer plants. The above figures do not include the P- and K-nutrients which are also available in urine. Therefore, it is unfortunate that we are unable to fully utilize this source of N-Nutrient.

Bricf mention should be made here about the utilization of urine. In the delta and moderate level regions in the north and the 4th War Interzone*, most families have earthen jars in which to collect urine. The stored urine undergoes biological hydrolysis and the available nitrogen is in simple forms that can be absorbed by crops. Before applying the urine to crops it is usually diluted 7 to 10 times with water. It can also be mixed with animal manure to increase the fertility of the manure. Some collectives buy

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* which includes Thanh Hoa, Nghe Tinh and Binh Tri Thien Provinces (TRANSLATORS' NOTE).

diluted urine to apply to young rice or vegetables. In Thai Binh province where Azolla originated, farmers are used to urinating in baskets of ashes. When the ashes are saturated, they are removed and stored and fresh ashes placed in the baskets. The ashes which have accumulated for 8 to 9 months are used for fertilizing the Azolla, and, in turn, the Azolla is used as green manure on the spring rice crop.

During the War of Resistance against France, people in the 5th War Interzone** supported the movement in building DSB and weaving ashes baskets for the collection of faeces and urine. The faeces compost and collected urine were used as fertilizers on rice and tobacco.

In the countryside each family should be encouraged to collect urine and to use the diluted urine as fertilizer for vegetables. If the urine is not used for vegetable cultivation it can be added to animal manure to increase the fertility of the manure. Production cooperatives should plan to buy urine to apply to vegetables and young rice, or to add to animal and rubbish manure. Adding urine to animal and rubbish manure piles increases the moisture of the piles and the fertility of the compost by increasing the nitrogen-to-carbon ratio, and accelerating the hydrolysis of cellulose, the substance most difficult to decompose.

Urinals should be built in public places such as schools and cultural houses, and the collected urine used by cooperatives for crops. In urban areas, many public urinals should be built, especially in places such as bus and car stations, markets and theatres. In the south, the number of public urinals is not enough to meet the demand. The construction of a public urinal is shown in Fig. 8. There should always be someone on duty to clean and maintain the urinals. They should be constructed so that they can be used by many people at the same time, and male and female urinals should be constructed separately. High surrounding walls should be built as shown in Fig. 8. The urine tank should be covered with wooden slats to keep out the rain and sun, and it should be raised about 10 to 20 cm above the ground so that rain

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** which includes three provinces : Quangnam - Danang, Nghia Binh and Phu Khanh (TRANSLATORS' NOTE).

water can not flow in.

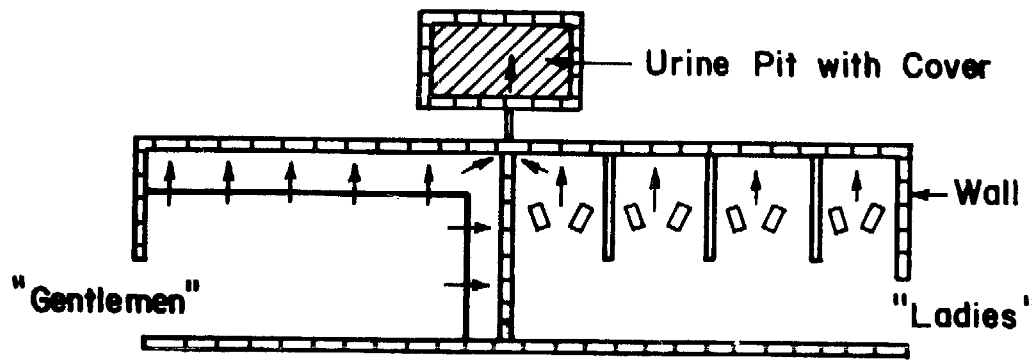

Fig. 8 Communal Urinal

HOW TO CONSERVE THE FERTILIZER VALUE OF URINE

Fresh urine is generally free from bacteria and viruses, except in cases where it has been discharged from persons with urological or veneral diseases. Once outside the human body, urine is quickly hydrolysed by microorganisms which cause ammonification and the loss of N-nutrient. The smell which is detectable around urine tanks is due to the evaporation of the ammonia.

To limit the loss of N-nutrient from urine a number of precautions can be taken:

1. The urine tank or container should be covered.

The tanks at public urinals should be covered to keep out the the rain and sun. Jars and bottles used for storing urine should be placed in shaded, windless places. Since a temperature of 25°C to 30°C is favourable to the microorganisms which hydrolyse the N-compound in urine, placing the urine jars in sunshine will accelerate the loss of N-nutrient. Experiments have shown that when urine is stored outdoors and uncovered, after 35 days only 32% of the N-nutrient is left; if it is stored outdoors and covered 75%

N-nutrient is left. When urine is stored indoors and covered, as much as 92% N-nutrient is left. The longer the urine is stored, the more N-nutrient is lost due to evaporation. Without cover and placed outdoors, the amount of N-nutrient left is 70% after 10 days, 60% after 20 days, 30% after 40 days, and only 20% after 60 days (Fig. 9). The smaller the quantity of urine stored, the faster the evaporation. In the summer, the loss of N-nutrient is higher than in the winter. N-nutrient can also be lost if the urine tank is flooded.

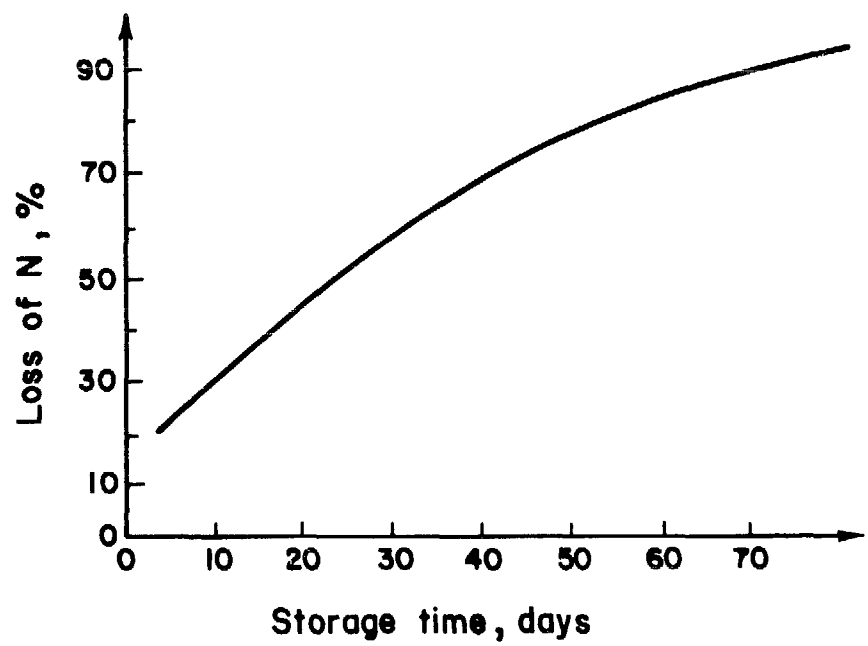

Fig.9 Loss of Nitrogen When Urine is not Covered

2. A layer of kerosene or vegetable oil should be poured on the layer.

Experiments have shown that after urine has been stored for 72 days, uncovered, or covered with kerosene, the percentage of N-nutrient lost is 90% and 57% respectively.

3. Super phosphate should be added to the urine.

Super phosphate is a chemical fertilizer synthesized by the reaction of sulphuric acid and apatite. Its chemical formula is : $(Ca(H_2PO_4)_2\ H_2O + 2CaSO_4)$ and some free phosphoric acids.

When super phosphate is added to urine or faeces, reactions occur between the ammonia and super phosphate, and ammonium sulphate or ammonium phosphate is formed which prevents the evaporation of ammonia. Experimental results have shown that urine stored for 7 days contains 63% N-nutrient, while urine stored for 14 days contain 38% N-nutrient. If 3% super phosphate is added to the urine then the percentage of N-nutrients left after the same time periods are 72% and 71% respectively (Fig. 10).

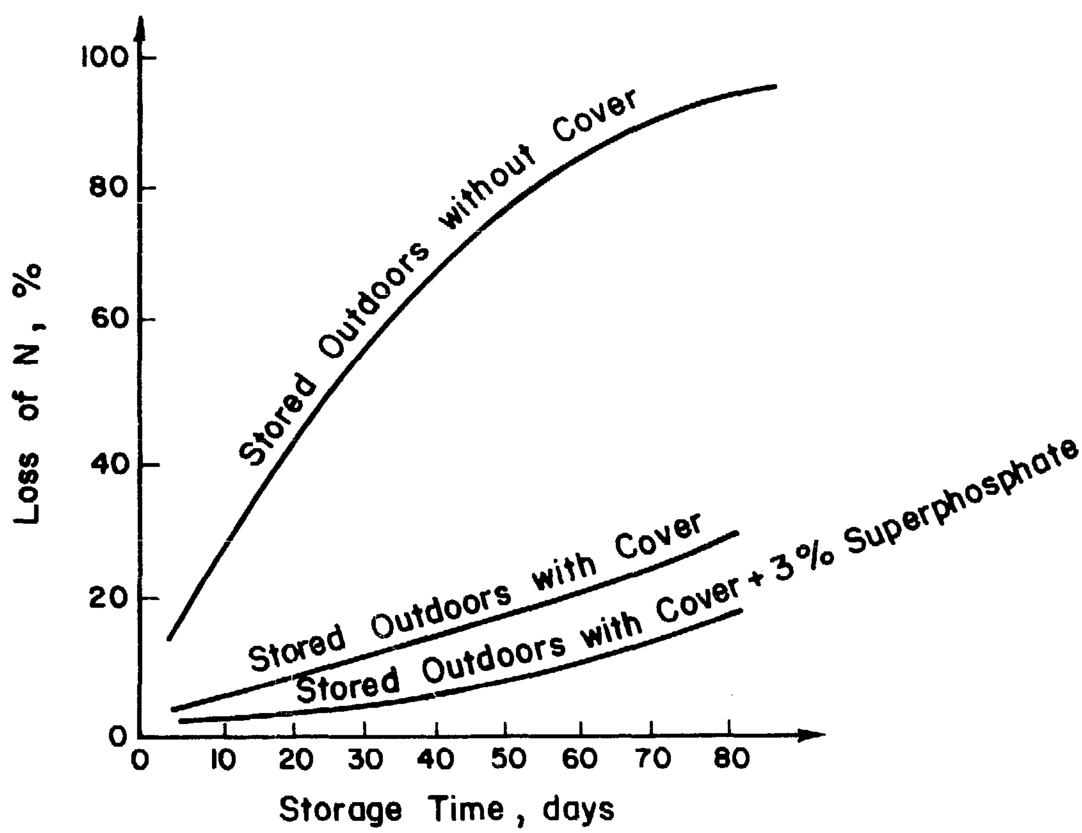

Fig. 10 Losses of Nitrogen vs Storage Methods

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Reactions between ammonia and compounds of super-phosphate are illustrated by the following equations:

$$(NH_4)2CO_3 + Ca(H_2PO_4)_2 \longrightarrow 2NH_4H_2PO_4 + CaCO_3$$

super-phosphate — mono ammonium phosphate

$$3(NH_4)2CO_3 + 2H_3PO_4 \longrightarrow 2(NH_4)_3PO_4 + 3CO_2 + 3H_2O$$

phosphoric acid — tri ammonium phosphate

Urea in the form of $(NH_4)_2CO_3$ is easily hydrolyzed and releases evaporating ammonia. If super phosphate is added, ammonia is retained in the forms of mono-, di- and tri-ammonium phosphate as shown above. Experiments with amounts of 3% and 5% of super phosphate have shown that the 3% amount is more economical since the quantities of N-nutrient lost after 60 to 70 days are similar.

4. Dried rubbish and soil powders should be added to the urine.

During the War of Resistance against France, farmers in the 5th War Interzone supported a movement towards "clean villages and fertile fields". Each family dug a rubbish pit with compacted base and walls, and roofed to keep out the rain and sun. Every day rubbish and soil powders were dumped into the pit and the pit was also used as a urinal. The pit was used for 1 to 2 months, then the mixture removed and piled up separately or with animal manure for further composting. The composted manure was used as fertilizer for sweet potatoes and cassava with a notable improvement in yields. Many similar pits, into which rubbish was collected, were built in public places and along walkways. Experience showed that if soil powders were not added to the pits, the N-nutrient evaporated almost completely after a time. It was also shown that for a same period, the amounts of N-nutrient left were 30%, 45%, 70%, 80% and 85% when 1, 2, 3, 4 and 5 portions of soil powder were added with one portion of urine, respectively.

5. The urine must be diluted and stored in a covered jar.

The urine should be diluted with water and stored in a tightly covered jar.

To summarize, the best way to collect and store urine is in a covered jar, pot or tank to which 3% super phosphate, or 2 to 3 portions of soil powder for each portion of urine, is added. The urine can be diluted and used for direct application on crops, or it can be added to rubbish and animal manures during composting.

The use of ashes must now be considered, since in fact ashes contribute to the evaporation of the N-nutrient in urine. Ashes contain about 81% to 89% silica (SiO_2), 0.6% to 1.2% K_2O, 2% to 4.1% P_2O_5 and 1.7% to 3.8% CaO. Ashes do not contain nitrogen compounds and therefore the application of ashes to crops is not beneficial. When ashes are used to absorb urine, the alkaline compounds in the ashes cause the evaporation of ammonia, according to the following reaction:

$$(NH_4)_2SO_4 + CaO \longrightarrow 2NH_3 + CaCO_3 + H_2O$$

The longer the urine is absorbed by the ashes, the more N-nutrient is lost, and an over-absorption of urine also causes a loss of K- and P-nutrients. Therefore it is advisable not to use ashes for absorbing urine, and if it is necessary to use ashes they should be replaced before they are too wet. The wet ashes can be composted together with animal manure or piled up in the processing house away from the wind and the rain and daubed with dried soil powder.

CHARACTERISTICS OF COMPOSTED HUMAN FAECES AND URINE FERTILIZERS

Generally speaking, composted human faeces and urine are good fertilizers which can be applied to any crop. However, they have their own characteristics which should be known so that they can be properly applied.

1. Human faeces and urine are organic fertilizers which produce very little humus, or none as in the case of urine. Therefore,

they should not be used as a basal dressing or main fertilizer, because the valuable nutrients would be wasted and the soil would become aggregated and compacted.

Experience has shown that when composted human faeces and urine are applied to crops for the first time, the yields increase sharply. However, on subsequent applications, the increase in yield is very slight and the soil becomes compacted. Urine does not produce any humus and faeces produce an insignificant amount. On the first application of urine and faeces to crops, the quantity of N-nutrient in the soil increases, thereby accelerating the activities of the microorganisms which, in turn, completely hydrolyse the humus available in the soil. Therefore, especially on sandy soils, human faeces and urine should only be applied to crops as an additive together with other farmyard manures.

2. Composted human faeces and urine contain a higher percentage of N-nutrient than many other organic fertilizers. About 80% of the total available N-nutrient is in the form of ammonia which can easily be absorbed by crops. These composts should therefore only be used for dressing applications and on crops with high market value, such as cauliflower, cabbages and onions, or on crops damaged by insects and which desperately need fertilizing for recovery. The composts need to be covered with earth after application to prevent the loss of N-nutrients.

3. Since human faeces and urine composts are of high fertility and are easily absorbed by crops, they can cause crops to overgrow and to produce underdeveloped grains if they are applied in large amounts, and moreover, the extra amounts of nutrients are used by weeds and/or wastedfully washed away. It is better to apply small amounts of compost at a time, especially on sandy soil.

4. Urine contains 2 to 3% urea, some uric acid, hippuric acid etc., which are beneficial to crops when hydrolyzed to ammonia. However, concentrations of urea greater than 0.05% can be toxic to some crops. Urine also contains about 33% mineral salts and therefore it should not be applied to crops

such as sugar cane where it reduces the sugar content, and tobacco where it lowers the quality of tobacco leaf. Other crops, however, such as beets, cabbage, cauliflower, potato and corn require large amounts of mineral salts, including ionic Na and Cl which are available in urine.

Table 8 gives the percentage of minerals found in the ashes of some crops.

Table 8: Percentage of Minerals in Ashes of Some Crops.

Crops	% in Ashes				
	Na_2O	Cl^-	K_2O	P_2O_5	CaO
Corn, grain	1.1	0.9	29.8	45.6	2.2
Corn, stick & leaves	0.8	-	27.2	9.1	5.7
Potato, root	3.0	3.4	60.0	16.9	2.6
Sugar Beet, root	8.9	4.8	53.1	12.2	6.1

THE APPLICATION OF HUMAN FAECES AND URINE COMPOSTS TO DIFFERENT CROPS

(TRANSLATORS' NOTE: In this part, "farmyard manures" and "faeces" shouls be understood as the composted ones, not fresh).

<u>To Rice Paddy</u>

Research on the effects of different fertilizers on rice paddy has shown that the first rice crop absorbs only 61% N-nutrient from fertilizers, 50% N-nutrient from farmyard manure, 30% N-nutrient from green manure and 56% N-nutrient from faeces. Young rice paddy absorbs mainly NH_4 , but in a mature state it is able to absorb both NO_3 and NO_2 . In dry fields nitrogen is absorbed as NO_3 and NH_4 whereas in flooded fields it is absorbed as NH_4 . For the "Chiem"# and "Xuan"## rice paddy, preplant topdressing application of faeces helps the young rice plants to develop their root systems and to grow quickly. In the North, 'Xuan" rice paddy is normally sown in the last weeks of November or the first weeks of December when it is usually cold and dry. Basal or boosting application with chemical fertilizers, especially urea, will damage the paddy. An application of 50 to 70 kg per "sao" (1 "sao" = 360 sq.m.) of faeces to the paddy will help it to develop quickly and to withstand the cold weather, since the faeces contains N-nutrients as well as a wide range of other nutrients. For the "Mua"### rice crop, it is beneficial to apply about 5 to 7 litres/sq.m. of urine which has been diluted 5 to 10 times. It should be applied when the paddy is just sprouting, about 5 cm high, and about 7 to 10 days before uprooting for replanting, when it stimulates the paddy to develop horizontal roots, and moistens the soil, resulting in easier uprooting.

The requirements for N-nutrients differ in the various stages of growth of the rice paddy. If the total requirement is 100% in the period from replanting to panicle initiation (tillering stage), rice paddy requires 10.9% N-nutrient; between tillering stage and booting stage it requires 47% N-nutrient, and from booting to the milk stage of the ripening phase it requires 39% N-nutrient. In other words, rice paddy requires about 96.5% total N-nutrient from replanting to milk stage and only 2.5% during the last stages. These figures clearly indicate that a boosting application of N-nutrient is essential for rice paddy, and the quality of the rice is also improved. Experimental data show that with the IR 579 variety, the protein content is 8.03% when no N-nutrient is applied, as compared to 8.44% when N-nutrient is applied to the

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"Chiem" rice: rice which is seeded in the middle of November and replanted 2-3 months later (TRANSLATORS' NOTE).

"Xuan" rice: an alternative to "Chiem" rice, characterized by its photoperiod-sensitivity (TRANSLATORS' NOTE).

"Mua" rice: rice sown in June and replanted in July (TRANSLATORS' NOTE).

rice paddy. The same amount of N-nutrient, if used for one basal application and two dressing applications, will increase the protein content to 9.61%.

Faeces should be used for boosting application before flowering. Where the rice harvest is to be used for seed, the rice paddy should have priority for the faeces compost. The compost should be applied just before the paddy develops young grains so that the grains will be healthy and well-developed. The water in the paddy field should be lowered before applying the compost.

A boosting application of 1 kg faeces will increase the rice grain harvest by 0.2 to 0.4 kg; this figure is comparable to other chemical fertilizers. A boosting application using urine-saturated ashes gives similar increases. If a boosting application of 900 kg urine-saturated ashes is used on a paddy field that has had 14 tonnes farmyard manure as a preplant application, the harvest of unhulled rice is 300 kg higher. That is, every 1 kg urine-saturated ashes increases the harvest of unhulled rice by about 0.33 kg.

To Potato

For a harvest of 25 tonnes of potatoes, the soil loses 96 to 120 kg nitrogen, 55 kg phosphorous, 250 kg potassium, 125 kg calcium and 25 kg magnesium. These nutrients have to be replaced by fertilizers. For every 10 to 15 tonnes/hectare preplant application of farmyard manure, a boosting application of 3 to 5 tonnes/hectare faeces compost, or a mixture of faeces and ashes should be used. With these applications, chemical phosphate and potassium fertilizers would not be needed. Signs that the potato crop is not receiving enough N-nutrients are yellow leaves and stunted growth. Signs of insufficient phosphate are small plants, dark blue leaves, straight stems, few branches, and many dark brown or black streaks on the leaves close to the ground.

Signs of insufficient potassium are dull, dry looking plants with dark blue leaves which curl upwards, small greenish-brown spots in the center of the leaves, and short internodes. Which fertilizers should be applied depends on the stage of growth and the appearance of the potato. However, the quantities of compost, as mentioned above, should meet the requirements for the normal development of the potato. Where there are signs of insufficient phosphate, 100 to 150 kg super-phosphate should be added to the composts, or 300 to 400 kg ashes/hectare.

To Maize

Maize is seldomly damaged by an over-application of fertilizers. For a harvest of 5 tonnes maize, the soil loses 110 kg nitrogen, 45 kg phosphorous, 90 kg potassium, 25 kg calcium and 25 kg magnesium. Therefore, for a harvest of 5 tonnes maize, 180 kg pure nitrogen nutrient is needed (110 x 100 = 180) i.e. 900 kg ammonium sulphate or 360 kg urine.

In its young stage, maize requires a large amount of N-nutrient. Analyses on the mainstalk of maize show that when it is about 20 cm high it contains 5.59% nitrogen, when it is 30 cm high it contains 5.62% nitrogen, when it is 60 cm high it contains 4.51% nitrogen, when it is 80 cm high it contain 2.67% nitrogen, and when it is 1 m high it contains only 1.37% nitrogen. When maize starts to flower, the nitrogen content in the leaves is reduced. According to the above figures, the nitrogen content in the main stalk of maize is high when it is young, and the requirement for N-nutrient during this period is only 5% of the total N-nutrient needed. The requirement for N-nutrient just before flowering is 58% of the total N-nutrient needed, and therefore dressing applications are necessary.

At present, we are trying to change from one harvest of long-day varieties of maize (5 months) in winter and spring to two harvests of short-day varieties of maize (90 to 100 days) in winter and spring. The new, improved varieties of maize include the hybrids No. 5 and 6, the selected varieties 2A and 2B, the hybrids MP/2 and 660, all in the North; and the early Thai and the selected variety Nha Ho in the South. These varieties can be harvested in 60 to 65 days during the winter and 50 to 55 days during the spring. With the new varieties, half of the amount of N-nutrient should be used for preplant basal dressing and the other half for boosting application. For preplant dressing, it is better to use farmyard manure mixed with a little faeces or chemical fertilizer; and for boosting application, chemical fertilizer is better. If two boosting applications will be given, the first application should be faeces and it should be applied when the maize has just begun to sprout leaves.

When there is moderately insufficient N-nutrient, the maize looks pale green or yellowish-green and it grows slowly. A sign of serious N-nutrient deficiency is when the veins or cells on the leaves close to the ground are dry (certain leaves start to become dry at the tips). Signs of mild phosphate deficiency are slow plant growth, and the leaves near the ground turn dark blue and then reddish purple. Serious phosphate deficiency is shown by brown and dried leaves. Signs of potassium deficiency are dark blue leaves, faded colour at the edge of the leaves which turn dark brown, low stems and short internodes. Generally speaking, signs of potassium deficiency are usually observed when maize is cultivated on hill soil, and not on lowland or alluvium soils.

To Vegetables

For a good harvest of vegetables such as cabbage, lettuce, tomato, cucumber and cauliflower, fertile soil and fertilizers are necessary. During their growth, organic fertilizers with high fertility such as farmyard manure, faeces and urine compost, and chemical fertilizers must be applied several times. Table 9 gives the quantities of nutrients required to obtain 1 tonne of vegetables. The amount of fertilizers needed can be calculated as follows:

A harvest of 20 tonnes tomato requires 90 kgs (4.5 x 20) N-nutrient, 100 kg (5.0 x 20) P-nutrient, and 100 kg (5.0 x 20) K-nutrient. Vietnamese farmers usually apply 10 to 15 tonnes farmyard manure/ hectare. Using 15 tonnes as an example, and referring to Table 1, the nutrients in this amount of manure are :

(15 x 1.61) = 24.15 kg N-nutrient (say 24 kg)
(15 x 1.59) = 23.85 kg P-nutreint (say 23 kg)
(15 x 3.105) = 46.57 kg K-nutrient (say 46 kg)

Referring to Appendix Table A1, the quantities of nutrient that must be added in the form of chemical fertilizers are :

(90 - 24) = 66 kg N-nutrient (330 kg ammonia sulphate or 123 kg urea)
(100 - 23) = 77 kg P-nutrient (385 kg super-phosphate)
(100 - 46) = 54 kg K-nutrient (108 kg potassium sulphate or 90

Table 9: Required Quantities of Nutrients to Obtain One Ton of Product. of Product.

Vegetable	Harvested Product	Required Quantity / Ton of Product		
		N	P	K
Head Cabbage	leaf	5.0	5.0	5.0
Cauliflower	flower	12.0	12.0	12.0
Cucumber	fruit	4.0	3.5	5.5
Tomato	fruit	4.5	5.0	5.0
Turnip (Brassica rapa)	root	4.0	4.0	5.5
Carrot	root	3.5	4.5	5.5
Asparagus	shoot	9.3	2.1	9.3
Salad (Lactuca sp.)	leaf	2.5	2.5	6.0
"Bina" vegetable (?)	leaf	4.0	4.0	7.0

kg potassium chloride)

In practice, however, crops do not completely absorb the nutrients applied, the quantities absorbed on a single application are 40% for the first season, 30% for the second and 17% for the third. Therefore, the first time fertilizer is applied, in order to satisfy a requirement of 66 kg N-nutrient, an application of 165 kg N-nutrient is needed ((66 x 100)/40). However, if fertilizers have been applied for many seasons, the crops can absorb 87% of the applied N-nutrient, and the amount of N-nutrient to be applied is only 75 kg ((66 x 100)/87).

If faeces and urine compost are to be used in addition to farmyard manures and chemical fertilizers, the quantities needed can be estimated with respect to the N-nutrient contents. Table 10 gives the equivalent amounts of composts and chemical fertilizers. For example, 1 kg of human faeces is equivalent to 0.025 kg ammonia sulphate or 0.01 kg urea. Generally speaking, faeces and ureas are used mainly for boosting application to vegetables. If applied at the time of planting, only a small amount should be applied, just enough to stimulate the development of roots. Faeces and urine cannot be considered for basal dressing like farmyard manure. For example, when 1 kg of urea is required for boosting application but urea is not available, 93.0 kg of faeces or 57 kg of urine should be used (Table 10). In chemical nitrogen fertilizers, there is only N-nutrient while in faeces and urine compost there are many other nutrients though these were not calculated for equivalent values. Farmyard manure is rarely used as a substitute for chemical fertilizers in boosting applications; similarly, chemical fertilizers are rarely used instead of farmyard manure for preplant basal dressing.

Table 10: Conversion Table for Different Composts and Chemical Fertilizers.

Farmyard Manure Compost	Human Faeces Compost	Urine Compost	Ammonium Sulphate	Urea
1.0	0.33	0.20	0.008	0.003
3.0	1.0	0.6	0.025	0.010
5.0	1.6	1.0	0.040	0.017
125.0	41.0	25.0	1.0	0.45
287.0	93.0	57.0	2.3	1.0

To summarize, farmyard manure applied as basal dressing should be supplemented with faeces composted with ashes and soil powder, or urine mixed with ashes. After that, faeces are used as boosting application for crops with a duration of 4-5 months. 1/5 to 1/10 dilutions of urine are used as boosting application for other crops. For leaf vegetables growing in winter, urine should be applied 2-4 times at intervals of 7-10 days.

Little urine should be used for turnips, and should be diluted

5-10 times since exessive nitrogen fertilizers tend to cause cracks on turnips. Urine composted with 3% of supperphosphate can also be used for turnips.

For water spinach, the 4th or 5th cutting should be done near the ground level, then well composted faeces should be used as boosting application. After each cutting, urine diluted 5-6 times is used. Cabbage and lettuce can be applied with diluted urine every 7 days.

For garlic, since garlic roots are short and near ground level, composted faeces should not be applied deeply. After a basal dressing, boosting application should be done 3-4 times at intervals of 20-25 days.

For onion seeded in a nursery, 240-360 kg of well-composted farmyard manure, or 60 kg of faeces should be applied for 100 before seeding. Before replanting, the upper 10 cm of earth should be well mixed with farmyard manure. After that, three boosting applications, and chemical fertilizer or diluded urine is used at the two other applications.

In some regions, cabbage tends not to curl. Urine and faeces, if used regularly, help cabbage to curl.

During the past years, farmers in many parts have fully utilized urine and faeces as fertilizer for rice, fruit trees, leaf and tuber vegetables. In every case, economic benefits are obvious: agricultural outputs increased while some amounts of chemical fertilizer were saved. Few exceptions are that too high dosages caused the crop plants to fall down.

Table 11 summarizes of benefits from fertilization with faeces and urine.

Benefits from application of faeces and urine vary depending on soils, cultivation methods, and season. Generally, 100 kg of faeces and urine help to gain additional yields of 16 kg paddy, 12 kg wheat, 5 kg cotton, 15 kg corn grains, 12 kg sorghum grains, 200-300 kg cabbage or 70 kg turnip.

Effects of application of composted faeces in the Soviet Union are presented in Table 12.

Table 11: Benefits of Organic Fertilization in the People's Republic of China.

Crop / Tonne/ha	Output, Tonne/ha				
	Rice	Early Corn	Late Corn	Curly Cabbage*	Bina Vegetable
Control, nil	1.54	2.23	2.08	6.89	5.64
Faeces, 6	1.95	2.60	2.82	11.39	7.48
Urine, 12	2.34	4.38	3.13	14.40	11.61
Ammonium Sulfate, .3	2.14	4.40	3.12	13.96	12.06

* (Brassica oleracea var sabauda)

Table 12: Benefits of Organic Fertilization in the Soviet Union.

Catagory / Tonne/ha	Output of Product			
	First Crop, Potato		Second Crop, Barley	
	Tonne/ha	%	Tonne/ha	%
Control, nil	1.33	100	2.50	100
Peat + Faeces, 9	1.88	142	2.88	115
Peat + Faeces, 18	2.13	160	2.81	112

EXPERIENCES GAINED IN THE COMPLETE UTILIZATION OF HUMAN FAECES AND URINE

Although there are places where the people have collected and utilized human faeces and urine efficiently, there are still many places where the people do not know how to utilize these sources of nutrients. Two categories of regions can be considered; on the first category, human faeces and urine have been utilized and in the second they have not been utilized.

Regions Where Human Faeces and Urine Have Been Collected and Utilized.

In these regions, a number of effective measures have been implemented. For example:

a. Investments have been made in equipment and materials owned by collectives, cooperatives and individual members. Attention has been given to repairing public urinals, toilets, urine storage tanks and processing houses. Materials such as bricks, cement and lime have been made available to individuals to repair their own toilets or to convert their toilets to double septic bins.

b. The amount of fertilizer needed has been estimated before every planting season and necessary action taken. Apart from the amounts of N-nutrients that the government provides, any deficiency has to be met with human faeces, urine, green manure or Azolla Therefore, estimates and plans have to be made in advance for buying and processing these sources of nutrients.

c. Systems for buying, collecting and processing human faeces and urine have been implemented by the cooperatives. The payments may be in the form of cash, unhulled rice or higher personnel grade, depending on the conditions in each region. For example, in mountainous regions, payments to the farmers were made in the form of rice to encourage them to build septic bins, and to collect and sell the faeces to the cooperative. As a result of this incentive, each family, on the average, sold to the cooperative 350 kg of faeces and filler compost per year. In some other areas, the grade for carrying human faeces and urine was the same as that for carrying farmyard manures, with the result that no one wanted to carry human faeces and urine. After changing the grading system, this problem has been solved.

d. The evaluation of compost fertility was simplified, a rough estimate of the amount of pure faeces in the compost sold by a family is made by counting the number of adults in the family and the number of children between the ages of 10 to 17. Payments differ for pure faeces and for faeces with fillers. For example, the price for 1 tonne of pure faeces is 4-5 "dong"#, or 12-20 kg unhulled rice or 30 points##, while the price for 1 tonne of faeces and filler is 2-2.5 piastres, the price for 1 tonne pure urine is 1.5 piastres or 10-15 points. In some places, faeces compost from brick septic bins fetch a higher price than that from earthen ones.

e. There are simple tests to detect cheating by diluting urine with water. For example, a young green banana leaf when dipped into pure urine will quickly wither. Another test for pure urine is to pour the can of urine into a tank. If the urine is pure, many bubbles will appear and last for a long time in the tank. Pure urine also looks thick and yellow and has many white suspended scales.

f. In some places, families are encouraged to grow crops in the household yards and on 5% of their alloted fields###. The cooperative then distributes faeces and urine compost to the families in March, April, September and November for use on the crops. During the other months, faeces and urine composts are bought for the collective fields.

g. In other places, the cooperative decides the amounts of

Vietnamese currency, approximately US$ 1 = 2.2 dong (TRANSLATORS' NOTE).

Points used to evaluate work done and for payment (TRANSLATORS' NOTE).

Farmers are allowed to cultivate, for their own income, private lots which have areas equal to 5% cooperatives' land that they are working on (TRANSLATORS' NOTE).

faeces and urine each family must sell. For example, every family member above 10 years old must sell to the cooperative every month 4 kg pure urine and 5 kg faeces with filler, or 2 kg pure faeces.

h. Teams responsible for collecting urine and faeces from public urinals and toilets, and for buying them from cooperative members have been organized. The team is also responsible for processing and composting the collected urine and faeces. Attention is given to the grading system of the team members, especially those who buy urine and faeces, and the team members are covered by insurance. Technical books about fertilizers and their application should be made available to the team members, and whenever possible, technical consultant cadres should be invited to give lectures on the processing and applications of compost. In some cooperatives, technicians have been made head of the collection teams.

In cities and towns, it is best to have sanitary state enterprises responsible for processing the collected faeces and for selling it to the farmers, so that hygienic standards can be maintained and infectious diseases prevented. Limited transportation of the compost should be allowed within the city. The farmers to whom the compost is distributed should be instructed by the sanitary state enterprises and agricultural officials on how best to utilize the compost.

Regions Where Human Faeces and Urine Have Not Been Collected and Utilized

In these regions, many problems face the government cadres and officials who are responsible for initiating changes to make the people collect and utilize human faeces and urine. It is very difficult to make people understand the use of fertilizers and to make them abandon their prejudices. Some people are reluctant to handle fertilizers and even more reluctant when the fertilizers are faeces and urine. This reluctance may be due to ignorance about fertilizers and the nourishment and development of crops; it could also be due to inexperience with fertilizers and their effects on crops, or because the land is fertile so that the extra work needed to apply fertilizers can be avoided. Therefore, there are no other ways but through organization and propaganda. Slogans such as

"Clean Village and Fertile Fields" and "Civilized Life Style" under which public urinals and toilets are built, and families are encouraged to have a double septic bin and urine jar can be effective. In parallel with these movements, encouragement should be given to some active villagers to build urinals and septic bins, and guidance on how to process, store and apply the composts should be offered.

At a later stage, a paddy field or corn or sweet potato field can be used as a demonstration field. The field is divided into two, half of which is applied with compost while the other half is not. The same can be done with a water spinach field or lettuce field, using urine as the fertilizer. 7 to 10 days after the fertilizer has been applied, a field observation trip has to be arranged, and later on a meeting should be held to discuss the benefits of utilizing human faeces and urine. The meeting also provides an opportunity to answer any questions.

In the provinces and districts, cadres and officials should be mobilized to build a number of demonstration villages so as to gain experience and to provide visible evidence to the people.

In the cities and towns, it is best to establish processing plants to collect and compost faeces, urine and other solid wastes. Human faeces and urine are the main components needed to provide good quality compost. Metals, tin cans etc. are separated from the solid wastes which are later ground and processed at the same time with the faeces and urine. The compost can be sold to farmers in the provinces. With such utilization and management of wastes, the hygiene of the city is improved and infectious diseases prevented.

Table A1 : Percentage of Nutrients in Some Chemical Fertilizers.

fertilizer	main nutrient	% (weight)	remark
ammonium sulphate	N	20.0	
ammonium chloride	N	25.0	61% chlorides
ammonium nitrate	N	35.0	
urea	N	46.0	
super phosphate (Lam Thao)	P_2O_5	17 - 20.0	50% calcium phosphate
phosphate (Van Dien)	P_2O_5	20.0	19% magnesium
phosphate (apatite mineral)	P_2O_5	20.0 - 25	46% lime
thermo-phosphate	P_2O_5	17 - 20.0	22% lime
potassium phosphate	K_2O	46	
potassium chloride	K_2O	50.0	some NaCl

Table A2 : Evaluation of the Equivalent Fertility of Some Organic Fertilizers in Order to Determine the Quantities Needed.

	Equivalant to
1 unit of cattle manure (in weight)	1 unit of fertility
1 unit of pig manure	1.3 "
1 unit of excreta	3.0 "
1 unit of urine	2.0 "
1 unit of mixture of human faeces and soil powder	2.5 "
1 unit of mixture of human faeces and kitchen ashes	2.0 "
1 unit of green manure	
- of leguminous plants (peanut, Sesbania sp. Crotalaria sp. stalk and leaves), Melia azedarach leaves, sweet potato vine.	2.0 "
- of wild tree leaves	1.0 "
- of rice stubble	0.5 "
1 hectare of water fern (Azolla)	7.5 "
1 unit of fresh pond mud	0.2 "
1 unit of dried pond mud	0.3 "

Table A3 : Quantities of Chemical Fertilizers Used in each Hectare in Different Countries.

Year	Country	Nitrogen N	Phosphorus P_2O_5	Potassium K_2O	Total
1970	Netherlands	431.8	120.7	138.1	690.6
	Switzerland	206.2	166.9	216.9	590.0
	Japan	160.1	123.0	123.2	406.3
	W. Germany	132.7	104.8	137.7	375.2
	France	64.3	67.2	68.3	199.8
	U.S.A.	38.4	33.5	20.7	92.6
	India	6.1	1.5	0.9	8.5
	Thailand	4.4	4	0.9	9.3
1972	RD of Germany	106.1	69.3	85.4	260.8
	Bulgaria	59.0	38.3	10.4	107.7
	Hungary	62.0	39.1	48.4	149.5
	Czechoslovakia	64.2	51.8	83.4	199.4

Table A4 : Chemical Composition of Some Organic Fertilizers.

Fertilizer	Moisture %	Fertilizer Value, %		
		N	P_2O_5	K_2O
Pig manure and urine, fresh, with fillers	72.9	0.784	1.55	1.206
Pig urine, fresh	96.7	0.430	0.11	0.83
Pig excreta fresh (aver.)	66.2	0.669	1.25	1.194
Cow dung, fresh (aver.)	73.8	0.341	0.22	0.958
Cow urine, fresh	93.8	0.580	0.05	1.30
Buffalo dung, fresh	82.3	0.306	0.17	1.360
Buffalo urine, fresh	83.9	0.47	0.41	1.30
Human faeces, fresh	78.9	1.993	1.12	1.275
Human urine	99.5	1.000	0.16	0.180
Human faeces and ashes as filler	28.27	0.485	1.26	4.211
Human faeces and dried mud as filler	-	2.76	0.85	-
Bat excrement	19	4.96	2.11	0.28
Chicken manure	40.62	1.12	0.98	1.01
Duck manure	79.2	1.153	0.97	1.489
Silk worm manure (some mulberry leaves)	36.5	1.809	0.60	2.122
Alluvium	-	0.15	0.13	0.950
Pond mud	-	0.156	0.249	0.642
Fermented fish cake	-	3.767	9.945	0.770
Fish meal	9.0	9.9	7.4	
Soot	-	1.30	0.40	2.4
Coconut cake, dried	-	3.64	1.99	-
Peanut cake, dried	-	6.41	0.45	0.40
Soy bean cake, dried	-	7.13	1.52	1.88
Azolla sp.	94.0	4.75	0.638	1.822
Crotalaria striata: leaves + stubbles	79.71	3.113	0.261	1.050
roots	80.14	0.886	0.216	0.866
Tephrosia sp.: leaves + stubbles	76.74	2.430	0.269	1.401
roots	63.89	1.185	1.146	0.660
Sesbania sp.: leaves + stubbles	-	2.660	0.279	1.780
roots	-	-	0.187	1.181
root nodules	-	4.09	0.900	-
Water hyacinth, young	-	1.79	0.164	-
Water hyacinth, old	-	0.969	0.405	-
Black bean	-	1.964	0.319	-
Pistia sp.	-	2.275	0.202	-
	-	2.65	0.52	2.48
Stubble ashes	-	-	1.20	4.1
Rice hush ashes	-	-	0.60	2.50
Fire wood ashes	-	-	2.00	3.80
Peat, low regions	2.0	0.5	0.050	0.03
Peat, high regions	10.0	2.5	0.25	1.00