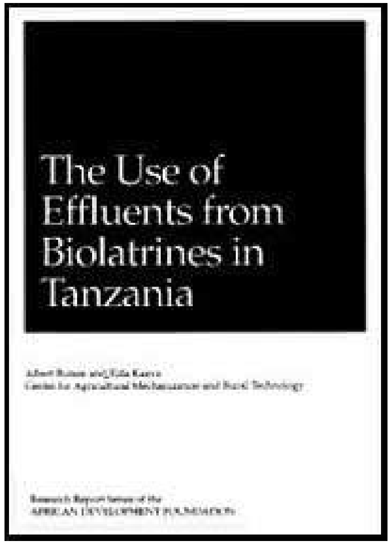

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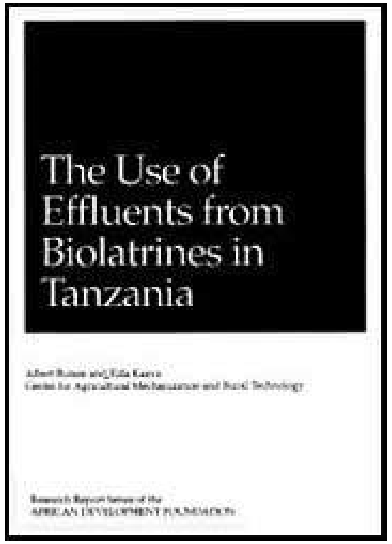

The Use of Effluents from Biolatrines in Tanzania (ADF, 1996, 38 p.)

Albert Butare and Elda Kaava

Center of Agricultural Mechanization and Rural Technology

Research Report Series of the
AFRICAN DEVELOPMENT FOUNDATION

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The opinions, conclusions, and recommendations expressed in this report are those of the authors and do not necessarily reflect the views or policies of the African Development Foundation.

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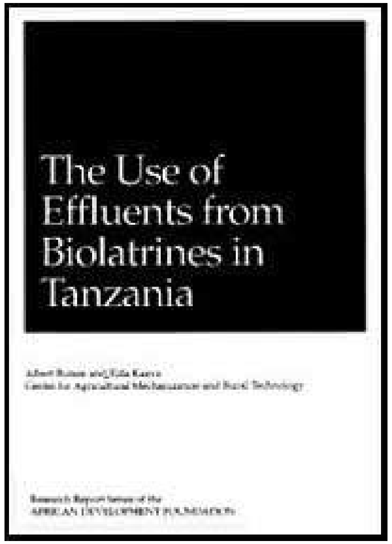


The Use of Effluents from Biolatrines in Tanzania (ADF, 1996, 38 p.)

Conclusions and recommendations

The use of excrete in agriculture and aquaculture is becoming increasingly important. The economic benefits of such use must be balanced against the associated public health risks, but these risks have often been exaggerated.

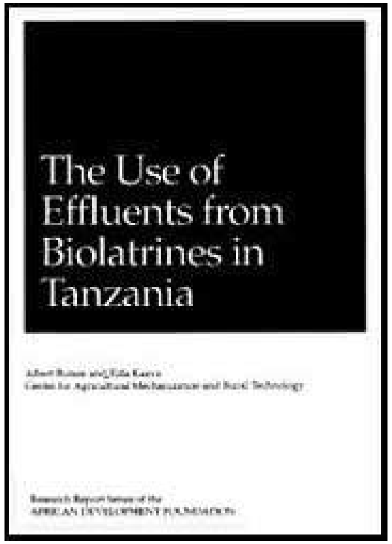
This research shows that recycling excreta through biolatrines and using the effluents as fertilizer is, in fact, safer than existing inadequate or non-existent methods of waste treatment. The risk of pathogen survival after biolatrine treatment is relatively small. Public health as well as agriculture would benefit substantially from adoption of this technology. Given the lack of resources for sewerage-based disposal systems, it is really the only viable alternative.

The most important variable to consider is adequate retention fume, a factor that must be taken into account in design of biolatrines with adequate capacity for the expected usage. When retention time is below 80 days, the effluents must be tested for pathogens before application in crop fields. When retention time is above 120 days, the effluents can safely be applied in crop fields without necessarily carrying out tests. For vegetables with short life spans like spinach and lettuce, however, effluents should only be applied after tests indicate they are free of pathogens. In this case, also, the application should be only once, before the vegetables are planted.

In addition to benefits for public health and agricultural production from properly managed biolatrine schemes, there are also potential benefits for the environment, as compared with sewerage systems. Biolatrine technology avoids the surface water pollution that might occur from discharge of wastes into rivers or lakes. It conserves fresh water resources used for flush toilets, and it conserves the soil on fields to which it is applied. By reducing the potential demand for artificial fertilizers, it conserves foreign exchange and possible pollution from industrial plants.

Human behavioral patterns are a key determinant in the transmission of excreta-related diseases in general, and no less in their transmission through excrete and waste water use. An ongoing campaign of public awareness is necessary to promote adequate understanding, acceptance and appropriate use of biolatrine technology. This campaign must include both the advantages of fertilizer use and the public health advantages.

It seems, nevertheless, that public resistance to biolatrines is less of an obstacle than finding the resources for biolatrine installation as well as public awareness campaigns. In order for biolatrine technology to spread around the nation in Tanzania, start-up and promotion efforts at a much larger scale than in Burundi will be needed. The question then becomes one of political will and available resources. One of the most important audiences to convince of the relevance of the technology is skill the policy makers responsible for such strategic decisions.



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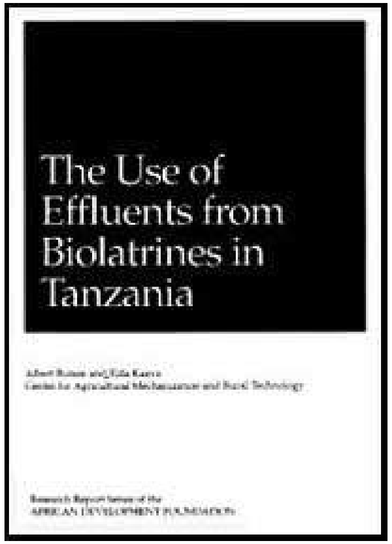

Appendix

Appendix 1. Production of Fertilizer at Tanzania Fertilizer Company Plant Tanga

1972-1990 (000 Mt)

Year	***S/A***	***TSP***	***DAP***	***NPK***	***Blends***	***Total***
1972	-	6.6	2.0	6.2	-	14.8
1973	4.7	9.9	-	1.7	-	11.6
1974	15.4	24.9	0.5	18.3	-	59.1
1975	18.0	19.7	-	1.6	-	39.3
1976	18.3	7.2	6.6	4.0	-	36.1
1977	15.7	8.3	-	12.8	-	36.8
1978	16.1	8.2	-	20.1	-	44.4
1979	25.4	4.5	-	8.2	9.1	47.2
1980	19.5	12.3	-	13.9	5.1	50.8
1981	24.9	14.5	-	13.2	14.4	67.0
1982	6.8	2.9	-	-	4.0	13.7
1983	14.8	7.1	-	.5	6.8	29.2
1984	22.6	8.8	-	-	20.2	51.6
1985	15.2	8.2	-	-	18.0	41.4
1986	19.3	3.5	-	-	24.2	47.0
1987	8.8	.5	-	-	10.0	19.3
1988	3.5	-	-	-	3.4	6.9
1989	14.9	3.4	-	-	8.8	27.1

Appendix 2. Analysis of Influent and Effluent, Oljoro Military Camp

Specimen	***Inf. 1***	***Infl. 2***	***Infl. 3***	***Holding***	***Effl.***	***Effl.***	***Effl.***
Salmonella	-	NSG	NSG	NSG	NSG	NSG	NSG
V. cholera	-	-	-	-	-	-	-
Shigella	NSG	NSG	NSG	NSG	NSG	NSG	NSG
P.E. Coli	-	-	-	-	-	-	-
Entamoeba	+	-	+	+	+	+	-
Ascaris	-	-	+	-	-	-	-
Trichuris	-	-	+	-	-	-	-
Hookworms	-	+	-	-	+	+	-
Schistosoma	-	-	-	-	-	-	-
Taenia	-	-	-	-	-	-	-

Tests were conducted at Nairobi University, March 1993.

NSG = No significant growth (noted)
- = negative
+ = positive
1, 2, 3: Different zones in the main digester

Appendix 3. Pathogens Found at Sampled Sites

Distance from	***Biogas***	***Oljoro***	***Livestock***	***Patandi***

digester bottom	***Extension Service 16 m²***	***Military Camp 32 m²***	***Institute, Tengeru 16 m²***	***Hospital, Tengeru 30 m²***
0.5 m	Ascaris ova	Ascaris ova	negative	negative
1.0 m	negative	Ascaris ova	Ascaris ova	negative
1.5 m	negative	negative	negative	Shigella dysenteriae

Pathogens tested for included salmonellas, shigellas, Vibrio cholerae, Path E.Coli, Entamoeba, Ascaris, Trichuris, Hookworms, Schistosoma, and Taenia.

Tests were carried out at Kenya Medical Research Centre, Department of Microbiology, July 1993.

Appendix 4. Pathogens Found at Sampled Sites

Specimen	***BES Biolatrine***	***Oljoro Military Camp Biolatrine***	***Livestock Training Institute Biolatrine***
Influent	Ascaris ova	Ascaris ova	Ascaris ova
Effluent	negative	negative	negative

Analysis was carried out in Mount Meru Hospital, Arusha, August 1993.

Pathogens tested for included salmonellas, shigellas, Vibrio cholerae, Path. E.Coli, Entamoeba, Ascaris, Hookworms, Schistosoma, and Taenia.

Appendix 5. Pathogens in Vegetables Irrigated with Biolatrine Effluents

Specimen	***Enter - virus***	***V cholera***	***Path. E. Coli***	***Shigella***	***Salmonella***	***Enteric Parasites***
M-onion	-	-ve	-ve	-ve	-ve	-
M-tomato	-	-ve	-ve	-ve	-ve	-
M-cabbage	-	-ve	-ve	-ve	-ve	-
M-carrot	-	-ve	-ve	-ve	-ve	-
B-cabbage	-	-ve	+ve	-ve	-ve	-
B-tomato	-	-ve	-ve	-ve	-ve	-
B-carrot	-	-ve	-ve	-ve	-ve	-
B-onion	-	-ve	+ve	-ve	-ve	-

The sample vegetables were from the test pilot at the Biogas Extension Service Office - Arusha.

Key: -ve = negative
+ve = positive
- = not done
M = Market sample
B = Vegetable fertilized by the biolatrine effluent

Appendix 6. Coliform Bacteria in Vegetables, Bacteria Count per Gram

Vegetable	***Brought from Arusha public***	***Picked from test garden fed on biolatrine effluent - Biogas Extension Service Office, Arusha***

	market	
Spinach	more than 2400/g	negative
Lettuce	75/g	11/g
Tomato	negative	negative

The laboratory tests were conducted at and by the Tanzania Bureau of Standards, Dar es Salaam, March 1993.

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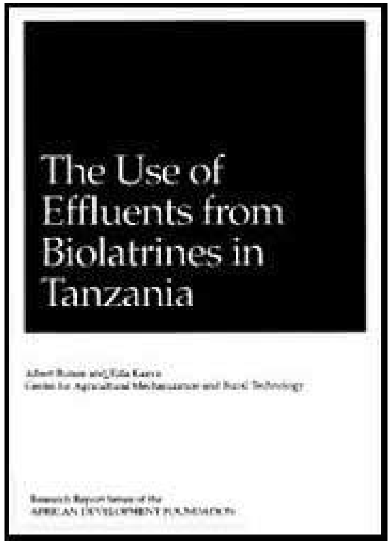

The Use of Effluents from Biolatrines in Tanzania (ADF, 1996, 38 p.)

Foreword

The African Development Foundation (ADF) *Research Report Series* presents the findings of studies undertaken as part of the Foundation's research grant program. The program is designed to support "action" research geared toward improving the overall quality, efficiency, and sustainability of self-reliant development. Research is carried out in concert with grassroots communities to understand and document the issues with which they are confronted. ADF expects researchers to explore problems directly related to grassroots development and to make concrete recommendations that will be useful to project designers and implementors, donor organizations, and government officials.

ADF's researchers are African scholars and development specialists, living and working on the Continent. The Foundation provides four different categories of research grants.

***Gray Senior Fellowships* - named in honor of former Congressman William H. Gray, III are awarded to academicians and development professionals who have demonstrated their commitment to grassroots development through careers in research, teaching, or public administration.**

***B Applied Research Grants* are provided to development professionals, scientists, and technicians who wish to study issues of direct significance to self-reliant development.**

***Leland Development Grants* are awarded to scholars who will study topics that have direct bearing on improving the quality of projects that ADF and other donors**

support on behalf of the rural and urban poor.

Finally, the Foundation gives *Knowledge Transfer Grants* to support the provision of training to, or the production of training materials for or by, grassroots communities. At the time this grant was approved, the Foundation also granted Doctoral Fellowships to African students completing their dissertations.

Dr. Albert Butare, an engineer at Tanzania's Center for agricultural Mechanization and Rural Technology (CAMARTEC), has worked on developing inexpensive biogas digesters for rural areas. Biogas technology treats animal in a standard digester, and human waste in a biolatrine, by breaking down the organic matter in an anaerobic environment, killing pathogens and organisms which may be present, and forming a liquid slurry. The bacteria which break down and ferment the organic matter, when adequately balanced, will produce methane gas. The gas can be used for cooking and lighting. The slurry from standard biogas digesters is used to fertilize crops, but the slurry from biolatrines has not. He was awarded a B Applied Research Grant in 1992 to analyze the effluent from biolatrine installations and to overcome societal resistance to using slurry as fertilizer.

In Dr. Butare's work, *Analysis of the Effluent from Biolatrines in Tanzania*, he states that effluent from the biolatrine is not used as fertilizer because of beliefs that the slurry is unsafe, as well as cultural restrictions. To overcome these restrictions, Dr. Butare sampled the effluent from several biolatrines for pathogens. He also conducted tests on soil and crops that had been treated with different types of fertilizer-animal manure, chemical fertilizers, and human slurry-to determine whether the use of slurry from the biolatrine produced harmful variations not present with animal manure or chemical fertilizers.

In all cases, Dr. Butare found that slurry from biolatrines is an effective fertilizer which does not expose the consumer to any of the risks assumed to be associated with human slurry. Additionally, demonstrations in the rural areas, where this technology would be most used, began to counter some of the taboos surrounding the use of human waste as a fertilizer. The Tanzanian government is already committed to the use of biogas as an energy source. An increasing number of households and institutions will be equipped with biolatrines and biogas digesters, resulting in readily available slurry for many rural Tanzanians. The costs are minimal and the slurry can be used to supplement or even replace more expensive chemical fertilizers, resulting in higher agricultural yields without increased costs.

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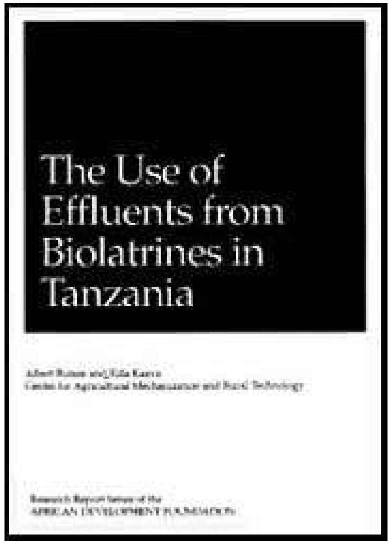

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Introduction

I. Biogas technology in Tanzania

Biogas technology was introduced in Tanzania in the early 1970s by the Tanzanian government's Small Scale Industries Organisation (SIDO). The primary objective was to promote renewable energy sources, in response to the crisis produced by rising prices of imported fossil fuels. Biogas technology was considered one of the best alternative sources, particularly for rural areas. SIDO adopted and promoted the Indian Gobar type of bio-digester, made of a steel floating drum to hold the gas, mounted on a masonry base. But SIDO was only successful in installing a small number of units by the late 1970s.

A nationwide survey of the installed units, conducted in the early 1980s, revealed a number of problems previously overlooked by SIDO. These included faulty installations, such as placement of the biogas digesters near kitchens but far from the animal stable, and badly mounted piping with resultant gas leaks. The focus was only on biogas as an energy source and slurry was rarely used as fertilizer. Without effective utilization of this additional output, the bio-digesters were not economically justifiable. The design requiring imported steel and trained metalworkers was costly. And there was inadequate follow-up after initial installation of the units.

Beginning in 1983, the Centre for Agricultural Mechanisation and Rural Technology (CAMARTEC), in collaboration with the German Agency for Technical Cooperation (GTZ), took over major responsibility for biogas activities from SIDO. The joint

CAMARTEC-GTZ Biogas Extension Services (B.E.S.) was based in Arusha, in northern Tanzania.

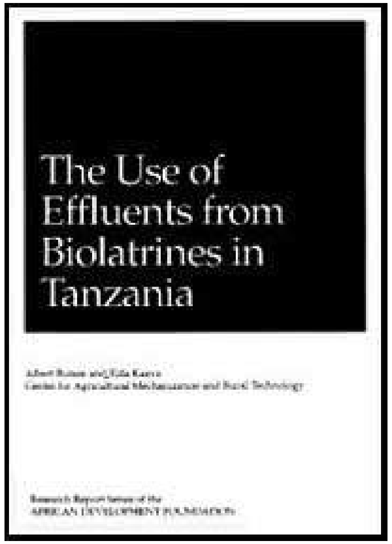
B.E.S. based its plans both on the previous experience of SIDO and on new international perspectives on biogas technology. For nationwide extension, it decided to promote an adaptation of the Chinese fixed-dome design, because this required only locally available materials.

By 1986, using the original Chinese design, B.E.S. developed a new, completely different, design-the CAMARTEC fixed dome-which was then the only non-steel crackproof fixed dome ever developed. The new design won international recognition and was adopted for the nationwide extension program.

II. The introduction of biolatrines

Biolatrines were introduced in Tanzania by CAMARTEC through B.E.S in a feasibility study in 1987. On the one hand this was an extension of previous biogas efforts aimed at solving the energy shortage, particularly by making biogas available to schools, institutions, and other communities who did not keep animals or cultivate crops that might provide organic material for inputs. But there were also other important objectives, specifically improving public health through better hygienics and sanitation, and providing additional effluents to be used as fertilizer in agriculture.

Despite the feasibility study's positive results, implementation on a wider scale has been difficult. That is the context in which this research was undertaken.



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The problem defined

I. Public health considerations

Tanzania, like many other developing countries, has a significant proportion of its population living in cities, municipalities, and rural shantytowns with relatively high population densities. Nonexistent or inadequate facilities for disposal of waste is a major public health problem, leading to the spread of infectious diseases, with resultant death and loss of productive capacity due to illness.

The conventional approach to addressing this problem in densely populated areas is through sewage systems and treatment plants, modelled after developed

countries. Yet this does not seem to be appropriate for many small towns in rural areas, shantytowns surrounding cities and municipalities, and rural institutions including schools, hospitals, prisons, and army camps.

The conventional approach falls short for a number of reasons. Only about 10 percent of the national population is directly connected to water supplies. Even this is seasonal, and vulnerable to climate and breakdowns in the supply systems. It is difficult to provide adequate maintenance and servicing even for existing waste drainage systems. Lack of funds and the lag time in construction make it even more difficult to expand systems at a pace matching that of population concentration in crowded areas. In short, there is an urgent need for cheaper and practical means for safe disposal of human wastes.

II. The need for alternate fertilizer sources

Most people, when they use the term fertilizer, think primarily of artificial fertilizer. This is a shortsighted approach, particularly when the availability of factory-processed mineral fertilizers is questionable.

In Tanzania, the entire national supply of artificial fertilizer comes from one factory, the Tanzania Fertilizer Company, based in Tanga on the northeast coast. This factory, in operation since 1972 has, theoretically, an installed capacity of 105,000 metric tons a year. But in twenty years of operation the maximum annual production achieved was 69,000 metric tons in 1981. In 1989, the most recent year for which statistics are available, production was only 27,000 metric tons (see Appendix 1).

This is only about 10 percent of estimates of the national fertilizer demand. And these estimates include only those few potential users who are aware of the importance of fertilizer, those who can afford it, and those who can be reached by this facility-probably fewer than 10 percent of the population involved in agriculture. The usage of artificial fertilizer in agriculture in Tanzania is, therefore, highly restricted.

On the one hand existing factory capacity is not utilized. The reasons for this vary, including lack of regular machinery maintenance; insufficient supply of spare parts and aging of production facilities; and shortage and untimely supplies of raw materials such as ammonia, sulphur, and sulphate of potash, due to foreign exchange constraints.

Outside the factory there are additional problems. The transportation infrastructure is inadequate for delivering fertilizer to users when it is needed. There are insufficient extension programs to educate the users on the importance and utilization of the fertilizer. And the costs are prohibitive for many rural communities.

Citing such problems, Mr. Ndekiro, the marketing manager of Tanzania Farmers Association (TFA) in Arusha, also noted that irregular output from the fertilizer factory also affected the viability of its suppliers. Minjingu Mines, which supplies rock phosphate, cannot count on selling all it produces. The tarmac road between Minjingu and Arusha rail head and the fifty special railway wagons meant to ferry rock phosphates from Arusha to Tanga are underutilized.

Both fertilizer imports (approximately 80 percent of supplies) and inputs for the

fertilizer factory require scarce foreign exchange. Under these conditions, there is little prospect of the fertilizer shortage being solved by artificial fertilizers.

III. Obstacles to biolatrine utilization

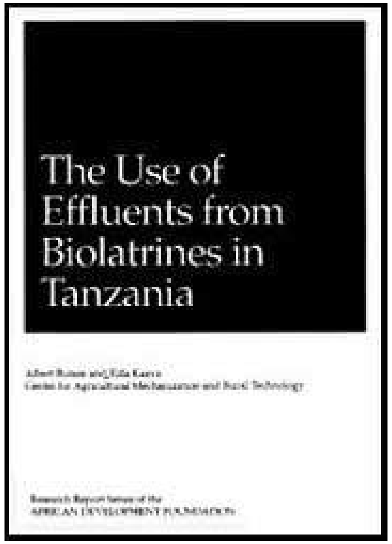
Biolatrines can provide a solution to the public health problem of waste disposal and to the agricultural problem of fertilizer shortage. But there are a number of initial obstacles that must be confronted and overcome.

Establishment of a biolatrine system, particularly one which includes effective mechanisms for usage of the effluents, requires capital investment in the initial facility as well as in maintenance. With effective use of the effluent for improved agricultural production, it may be possible to reach a break-even point of additional income to cover the investment. But it is unlikely that the prospects will be good enough to justify commercial loans to start-up biolatrine projects.

There is also a major problem of public acceptance for biolatrine technology, given cultural, traditional, and religious values and fears concerning the use of human excrete. There is resistance to the idea, including among literate opinion-makers who might be expected to take the lead and who are responsible for making decisions on behalf of institutions.

Some people go as far as not accepting biogas in their kitchen as long as it has been produced from human excrete. It will be even more difficult to convince them to accept the bio-effluents from the same digesters for usage on their fields. There is suspicion of the safety of plants grown using such fertilizer. Promotion of biolatrine technology requires a significant push from the government. It can only

be effective if first demonstrated in institutions such as schools and colleges, hospitals, prisons, and army camps. Reluctance to adopt the technology can be overcome only by practical demonstrations of its usefulness and safety, followed by extensive efforts at promotion.



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Biolatrine technology

Almost all kinds of organic wastes can be recycled into valuable products, provided the processes for treatment and disposal or reuse of these wastes are well considered in the initial design of treatment facilities. It is also necessary to

consider the potential for pollution and the possible diseases associated with handling and recycling of animal and human wastes.

Human waste, in particular include excreta, waste water, discarded food residue, and other solid household wastes. Excreta refers to the combination of faeces and urine, normally of human origin. When diluted with flushing water or other grey water (such as from washing, bathing, and cleansing activities), it becomes domestic sewage or waste water. Another type of human waste, called solid waste, refers to the solid or semisolid forms of waste discarded as useless or unwanted. This includes food wastes, rubbish, ashes, and other residues. Food wastes, which are mostly organic, are particularly suitable for recycling.

The quantity and composition of human excrete, waste water, and solid wastes vary widely from location to location depending upon, for example, diet, socio-economic factors, weather and water availability. Generalized data may not be readily applicable to a specific case, and design of the biolatrine system should be preceded by field investigation at the intended sites.

I. Bio-digestion and biogas generation

Excreta, being an organic waste, is biodegradable. As it is digested, or biodegraded, by bacteria, part is converted into the end products of methane and carbon dioxide and part is converted into bacterial cells. Under anaerobic conditions, i.e. without air, the portion converted into bacterial cells has been estimated to be from 2 to 5 percent (Roscol F. Ward 1985).

In the bio-digestion process, biogas production results in methane and carbon

dioxide. The remaining slurry loses most of the smell of excrete, and becomes more liquid than fresh excrete. These changes are caused by different bacteria working on the original matter input.

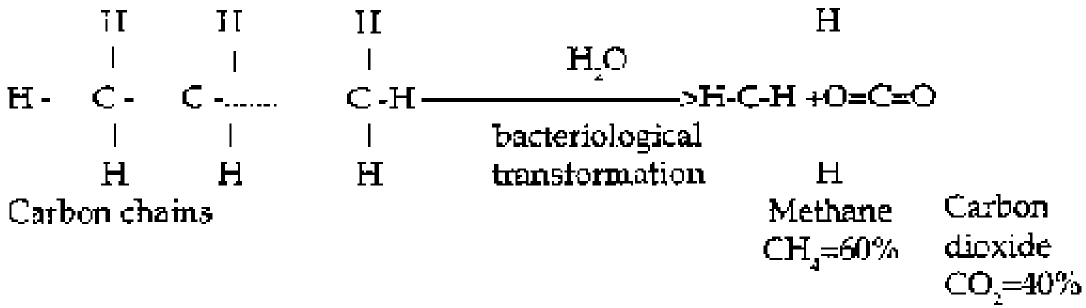


Figure 1: Biogas Generation

THE BIO-LATRINE INLET TOILET CHAMBERS UNDER CONSTRUCTION.

THE BIO-LATRINE OUTLET OPENING UNDER CONSTRUCTION.

The most important chemical principle at work is the transformation of longer carbon chains such as cellulose, alcohols and organic acids (which form a good part of the fresh excrete) into short carbon molecules like methane (CH_4) and carbon dioxide (CO_2). See Figure 1.

Cellulose takes longer to break up and often stays for a considerable period. The smell of excreta is mainly caused by organic acids (carbon chains with a certain oxygen content) and aromatics (carbon chains in ring form).

The bio-digestion process works best under a restricted range of conditions. The minimum temperature is about 15°C. The maximum is 45°C and the optimum range is 30-35°C. Even more important than the temperature is temperature stability. Changes of more than 2°C per day are harmful to the process, since the bacteria adapt rapidly to prevailing conditions and must readapt when the temperature changes. Acidity is also a significant constraint, with the optimum ph range 6-8. Methane-producing bacteria are negatively affected by acidity outside these limits. Retention times are another significant variable, which will be

discussed below.

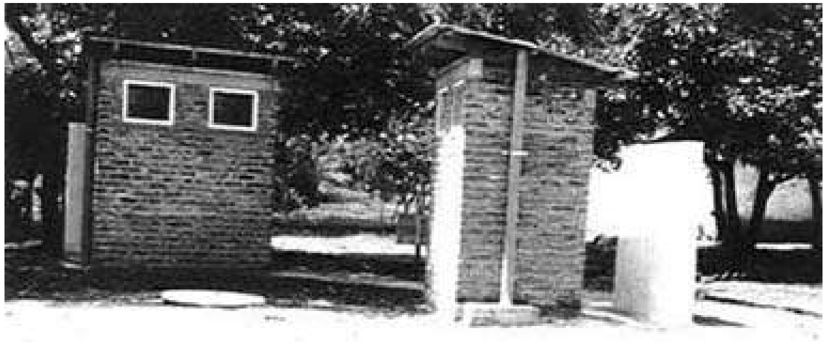
II. Biolatrine design

Biolatrines are integrated units, consisting of ventilated improved pit latrines, with septic tanks attached. The septic tanks, which serve as bio-digesters, differ from normal septic tanks in that processing is carried out in an anaerobic environment. The treatment of waste is more thorough than in a normal septic tank, and there is an outlet for the biogas produced in the process.

a. Size Requirements

Biolatrine units differ in size depending on several factors including the quantity of feed stock or the number of users; the climate, since temperature differences may require variation in retention time of the feed stock; the nature of the user community, and social and economic conditions affecting diet.

The nature of the community may require different-sized units. Schools and army camps, for example, normally have break periods during the day when many people visit the toilets at the same time. Such peak moments make necessary installation of more seats, although the total volume over a day's period may not be correspondingly increased.



THE COMPLETED BIO-LATRINE UNITS.

More generally, the quantity and the composition of excrete is directly related to the social and economic conditions and living habits of the community, via the effects on diet and health. Literature surveys by Feacham et al. (1983) found the quantity of faeces production in Africa and other developing countries to be between 130 and 520 grams (wet weight) per capita daily, while that in some European countries and North America to be between 100 and 200 grams (wet weight) per capita daily. Most adults produce between 1 and 1.3 kg of urine daily depending on how much they drink and the local climate. These figures are consistent with those obtained from the biolatrines installed in Oljoro Military Camp and Biogas Extension Service in Arusha, Tanzania.

The content and nature of pathogenic microorganisms found in faeces also depends on such background factors. The food consumed, food handling practices, the quantity of water available and other similar factors produce feed stock for biolatrines with distinctive characteristics.

b. Retention Time

The retention time is the period for which the digester feedstock has to stay in the

bio-digester before the first overflow (effluent) can be safely extracted. Calculating this time period appropriately is a key factor in successful management of biolatrines.

The necessary retention time can be affected by temperature. High temperatures speed up the microbiological processes and shorten the retention time. Lower temperatures correspondingly lengthen the recommended retention time.

In anaerobic processing in developed countries, the digesters are often artificially heated to allow fast treatment of large volumes of waste. This is an expensive exercise, and in developing countries bio-digesters normally depend on natural prevailing conditions to establish the temperature. In Tanzania, average ambient temperatures range between 10°C (in colder parts and cold season) and 38°C in coastal areas and hot seasons.

Under these conditions, the recommended retention time for human excrete is about 100 days. CAMARTEC designs including an additional safety factor are premised on an average retention time of 150 days. This allows for unpredicted feed additions. In addition, as Roscol F. Ward (1985) points out, if improved health is a consideration (i.e. destruction of most pathogenic micro-organisms), then it is advantageous to err on the side of caution with higher temperatures and longer retention times.

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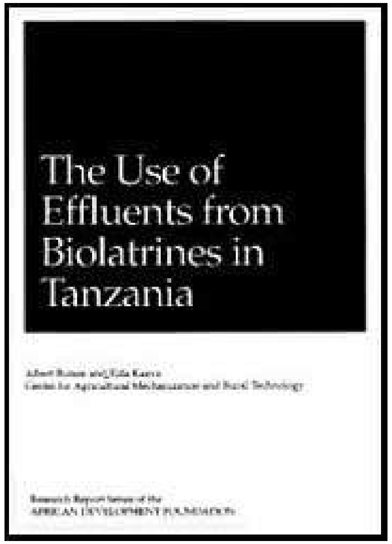


The Use of Effluents from Biolatrines in Tanzania (ADF, 1996, 38 p.)

Public health aspects

In developing countries, excrete-related diseases are very common. Excreta and waste water contain correspondingly high concentrations of excreted pathogens - the bacteria, viruses, protozoa and helminths (worms) that cause diseases in humans. There are approximately thirty excreted infections of public health importance. One must consider these infections in schemes for use of excrete and waste water.

There has been a tendency to examine the infectious-disease risks of excrete use

from a strictly environmental perspective and to assume that the potential risks presented by the presence of pathogens in excreta (both treated and untreated) will result in disease or infection. This reasoning has led, in some countries, to stringent regulations on the use of excrete. Much of the literature on the subject recommends restricting the free use of bio-effluents.

It is important, however, not to exaggerate these risks. An actual risk to public health from agricultural or aquacultural use of excreta requires a series of conditions. In many circumstances usage of adequately treated bio-effluents is quite safe. The sequence of events required to produce an actual health risk is summarized in Figure 2.

An infective dose of an excreted pathogen must reach the field or pond, or multiply in the field or pond to form an infective dose. This infective dose must reach and infect a human host, and this infection must cause disease or further transmission. If some of these conditions are not fulfilled, the risk to public health is only potential and not actual.

Figure 2: Influences on the sequence of events between the presence of a pathogen in excrete or waste water and measurable human disease attributable to excrete or waste water use

Excreted Load

latency
multiplication
persistence

treatment survival

Infective Dose Applied to Land/Water

persistence
intermediate host
type of use practice
type of human exposure

Infective Dose Reaches Human Host

human behavior
pattern of human immunity

Risks of Infection and Disease

alternative routes of transmission

Source: International Reference Centre for Waste Disposal (IRCWD) - WHO Collaboration Centre for Waste Disposal, Report 05/85

Table 1: Relative Health Risks from Use of Anaerobically Treated Excreta, by Retention Time

Pathogen	Retention Time (months)						
	1st	2nd	3rd	4th	6th	8th	10th
	M	M	M	M	M	M	M
Enteric viruses	+	+	0	0	0	0	0

Salmonellas	+	+	0	0	0	0	0
Shigellas	+	+	0	0	0	0	0
Vibrio cholerae	+	0	0	0	0	0	0
Path.E. Coli	+	+	0	0	0	0	0
Entamoeba	0	0	0	0	0	0	0
Ascaris	++	++	++	++	+	+	+
Trichuris	++	++	+	+	+	+	0
Hookworms	+	+	0	0	0	0	0
Schistosoma	0	0	0	0	0	0	0
Taenia	++	++	++	++	+	+	+

0 probable complete elimination
+ probable low concentration
++ probable high concentration
Source: Warner Baumann (1980)

All pathogens will eventually die or lose viability after excretion and release into the extra-host environment. In general, the reduction of viable pathogens is rapid in the first few hours or days after excretion, with a reduced number surviving over an extended period.

Variations of this die-off pattern are found with a few bacteria (e.g. Salmonella), which may temporarily multiply outside the host. Most helminths have one or more non-infective intermediate development stages with different die-off

periods. A further variation is found with trematodes (e.g. Schistosoma), which have a multiplication phase in intermediate hosts.

Basically, pathogen die-off follows the same pattern, independent of the environment (such as in soil, on crops, in sludge, or in excrete in a latrine or leaching pit). Particular environmental factors, however, determine the actual die-off rate and the number of organisms surviving within a given time period. This, in turn, determines the time required to obtain a "safe" or "reason ably safe" product. The relative levels of risk and main environmental factors which influence pathogen die-off are shown in Tables 1, 2, and 3.

After disposal on land, the process of pathogen die-off continues although at different rates for each type of pathogen.

Whether there is a potential risk of pathogen transmission through soil or crops in a particular situation depends on numerous factors. Pathogen survival or die-off is dependent on the organism's persistence and the adverse environmental effects such as sunlight, desiccation, and soil properties. Residual pathogen levels on root crops are expected to be higher than on crops growing above ground because the exposure of root crops to sunlight and desiccation is lower.

Potential contamination of crops is also dependent on the time and method of excreta application to the field. Contamination of leaf and fruit crops is likely to be minimal or nil if the excrete is applied prior to plowing, sowing, or transplanting. However, crops may become contaminated through rainfall splashing or if they fall on the ground before they are harvested. The interval at which night-soil is applied to the field also plays a role. The potential risk of pathogen transmission

from night-soil to farmers and consumers is greater if disposed of repeatedly on the same field during the crop growing period than if night-soil fertilization takes place only during the initial phase of the growing season.

Table 2: Likelihood of Infection by Class of Pathogen

Class of Pathogen	*Excess Frequency of Infection or Disease*
1. Intestinal nematodes	high
Ascaris	
Trichuris	
Ancylostoma	
Necator	
2. Bacterial infections	lower
Vibrio cholera	
Salmonella typhi	
Shigella dysenteriae	
Path. E. Coli	
3. Viral infections	least
viral diarrhoeas	
hepatitis A	
4. Trematode & cestode infections	from high to nil, depending on the particular excreta, usage of effluent and other local circumstances
Schistosomiasis	

Schistosomiasis	
Clonorchiasis	
Teariasis	

Source: IRCWD News No. 23 (1985) "The Engelberg Report."

Finally, the potential risk to those working in the field depends on the risk behavior of the workers, i.e. protective measures at work such as the wearing of shoes or boots (particularly to protect against hookworms and schistosoma infection), and habits of personal hygiene such as the washing of hands and body.

As mentioned above, most of the pathogens are inactivated within the first few hours or days after excretion. A few organisms, however, remain alive and infective for prolonged periods of time. Thus, the length of the time between night-soil application to a field and cultivation or harvesting is decisive for the risk of pathogen transmission through either soil or crops. If night-soil is applied only at the beginning of the growing season, it is important to ask whether excreted pathogens will die off within the growth period of the vegetable, or whether large numbers of pathogens will remain infective even at the time of harvest.

Table 3: Environmental Factors Influencing Pathogen Die-Off

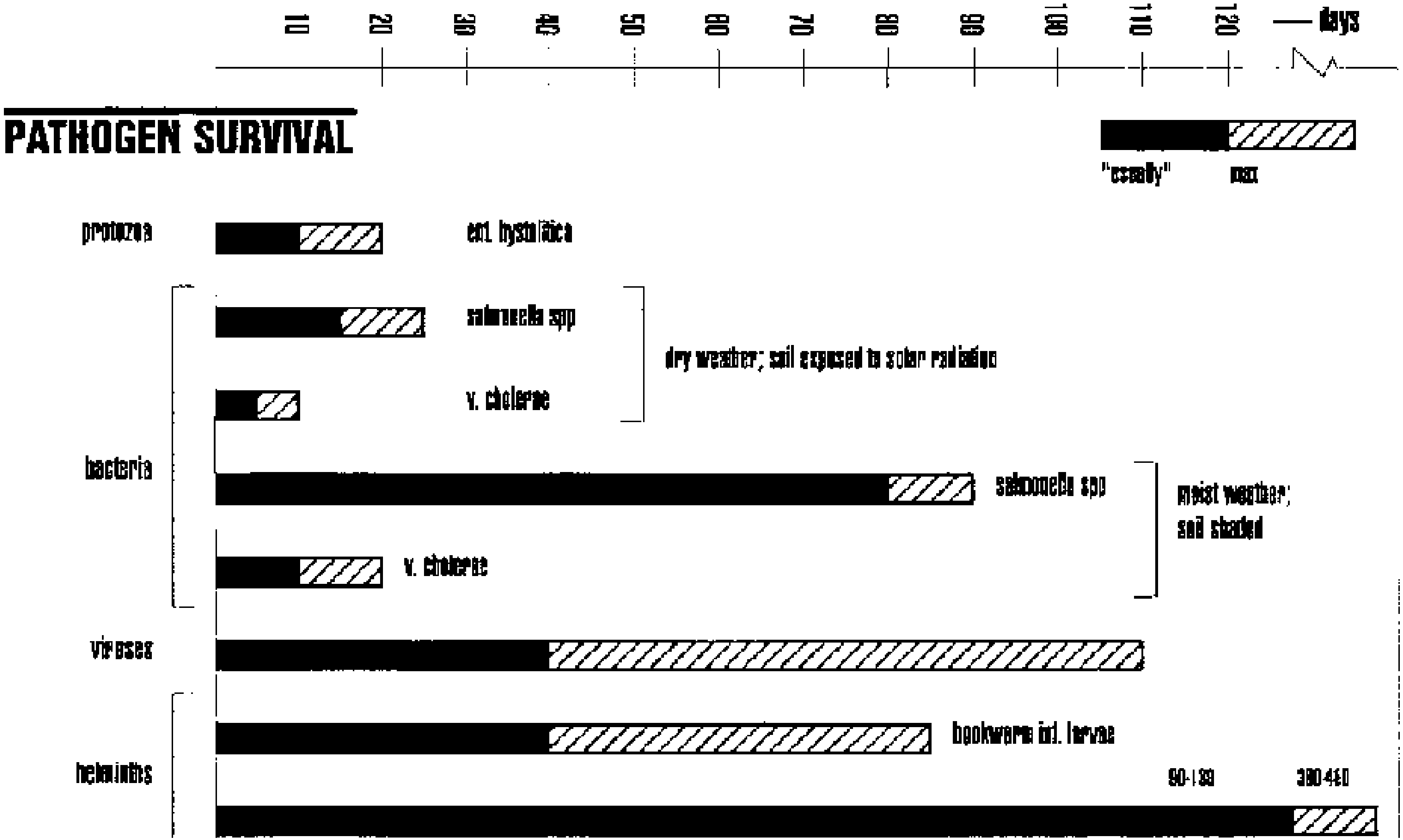
Environmental Factor	***Effect***
Temperature	Accelerated die-off with increasing temperature, longer survival at low temperature
Moisture content	Generally longer survival in moist environment and under humid

	weather conditions, rapid die-off under conditions of desiccation
Nutrients	Accelerated die-off if essential nutrients are scarce or absent
Elimination by other micro-organisms	Longer survival in an environment with few or no micro-organisms competing for nutrients or acting as predators
Sunlight (ultra-violet radiation)	Accelerated die-off if exposed to sunlight
ph	Neutral to alkaline ph tends to prolong survival of bacteria, acid ph tends to prolong survival of viruses

Figures 3 and 4 compare vegetable growth periods and excreted pathogen survival times in soil and on crops in warm climates. Figure 3 shows that Ascaris lumbricoides eggs have normal survival times in soil and tend to live past the period required by most vegetables to reach maturity. Excreta fertilized crops are, therefore, potential transmitters of A. Lumbricoides eggs where ascariasis is endemic. Hookworm larvae, though normally dying off substantially faster than A. Lumbricoides, have survival periods in soil which are of the same order of magnitude as the growth period of vegetables such as radish, spinach, and cucumber. They pose an occupational risk to those who perform weeding and thinning work in the night-soil fertilized fields. Ascaris eggs, apart from being transmissible via crops, may also be carried into homes by people who work in the fields.

As a rule, survival of pathogens on crops tends to be substantially shorter (by a factor of more than two) than survival in soil. This is not unexpected since pathogens are subjected to harsher environmental impacts (solar radiations,

desiccation, temperature) on crops, notably high-growing crops, than in soil. The majority of pathogens exhibit survival periods which are normally shorter than the growth periods of most vegetables exceptions being the eggs of ascaris or taenia saginata, and the salmonella on root and low growing crops.



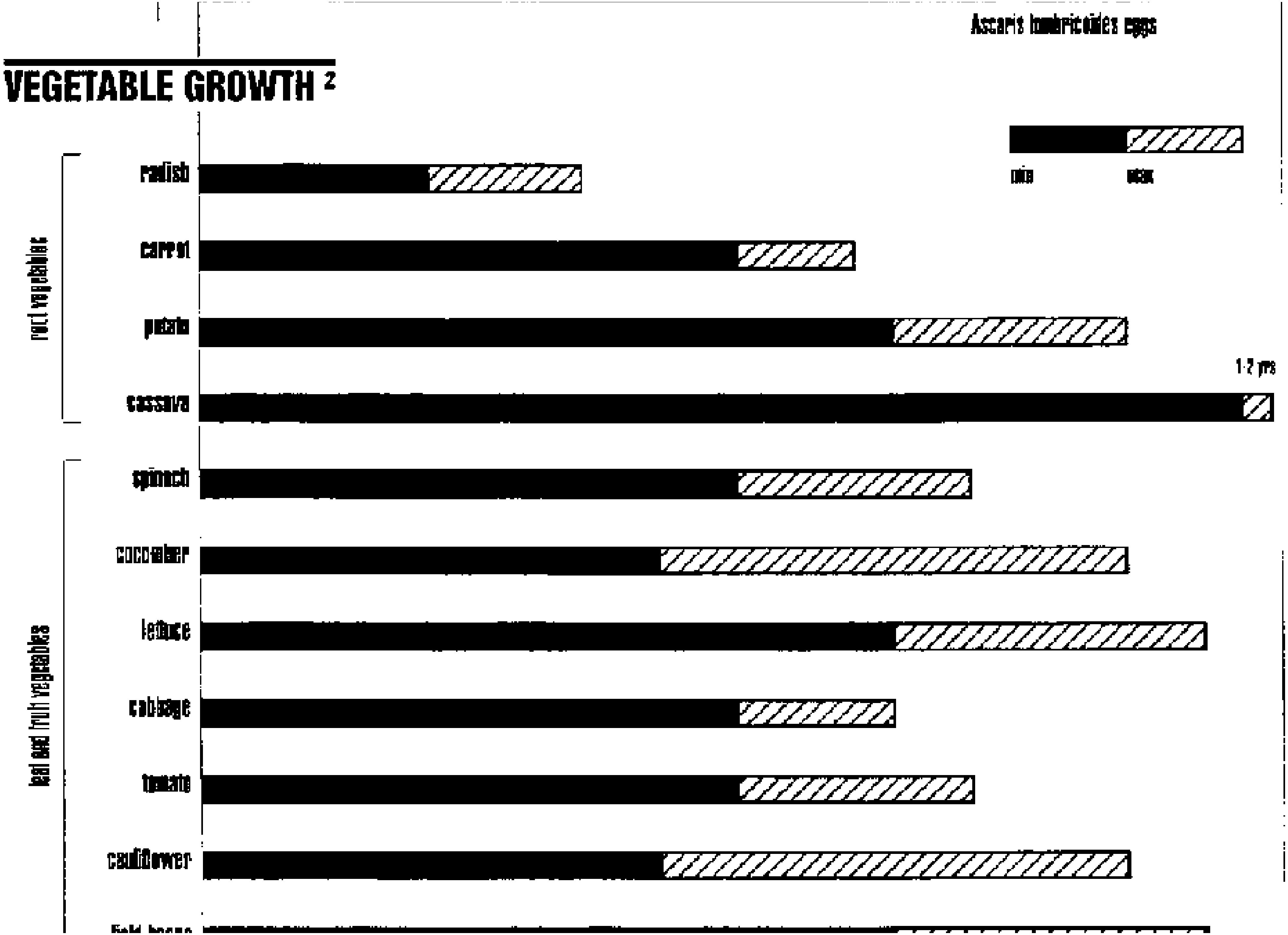
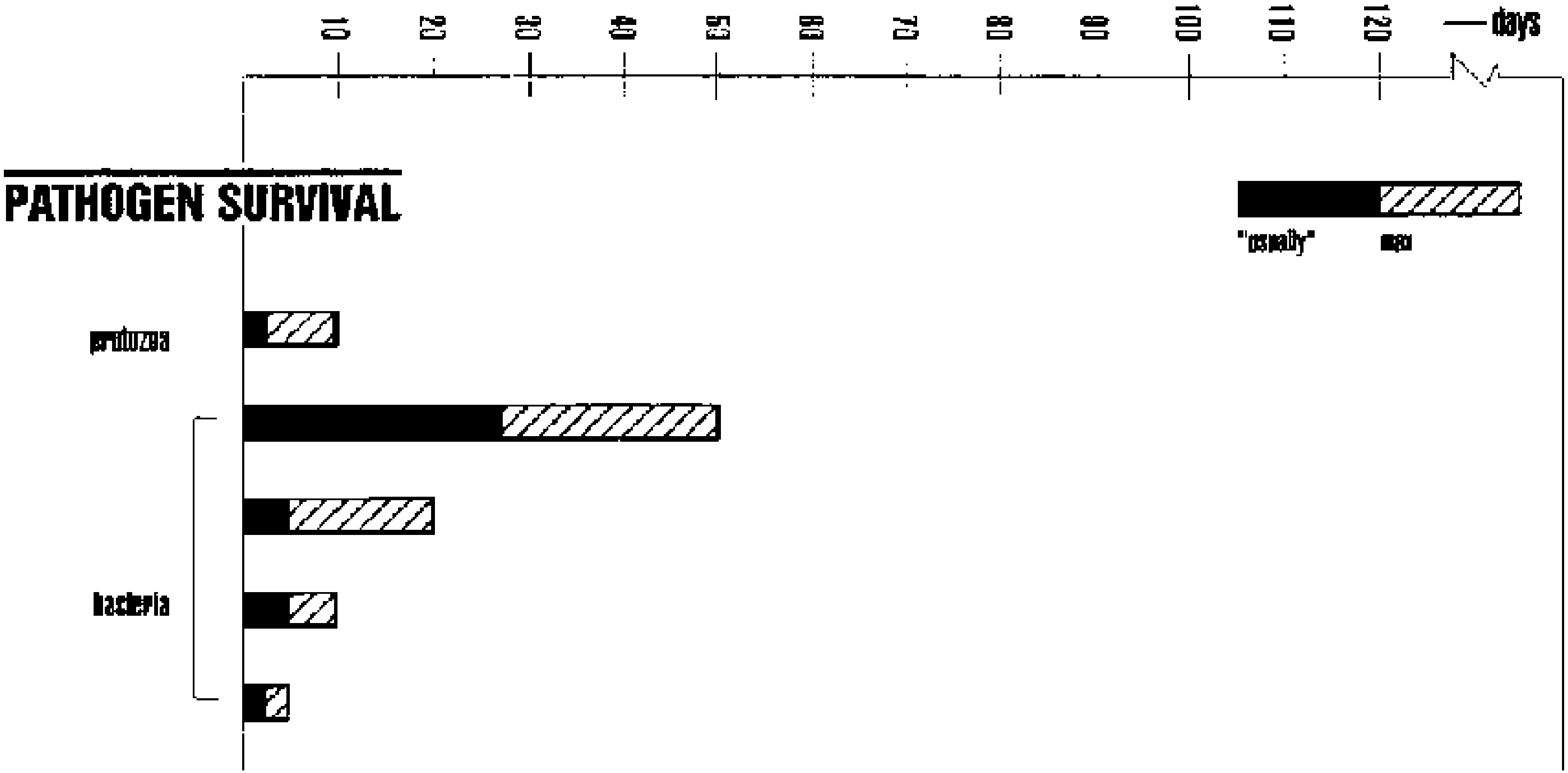

VEGETABLE GROWTH 2
Ascaris lumbricoides eggs
min
max
root vegetables
radish
carrot
potato
cassava
1-2 yrs
leaf and fruit vegetables
spinach
cucumber
lettuce
cabbage
tomato
cauliflower

Figure 3: Pathogen Survival in Soils vs. Vegetable Growth Periods in Warm Climates[1]

1 Determined under widely varying conditions

[2] Maturation period from transplanting or from sowing if not transplanted

***Source*: Strauss, M. (1990): *Survival of excreted pathogens in excreta and faecal sludges.* Report No. 04/85 of IRCWD.**



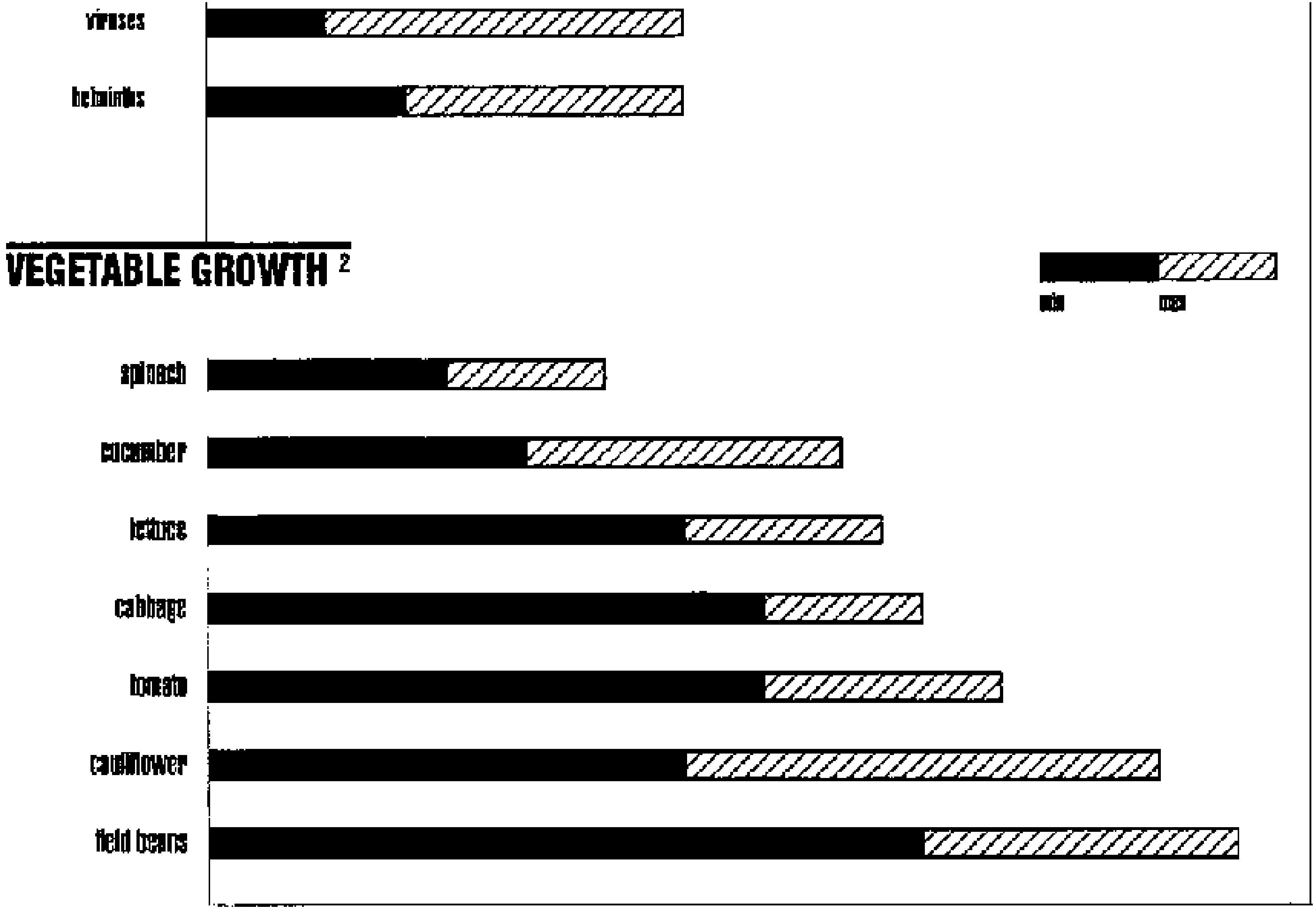


Figure 4: Pathogen Survival on Crops vs. Vegetable Growth Periods in Warm Climates[1]

1 Determined under widely varying conditions

2 Maturation period from transplanting or from sowing if not transplanted

Source: Strauss, M. (1990): *Survival of exacted pathogens in excreta and faecal sludges.* Report No. 04/85 of IRCWD.

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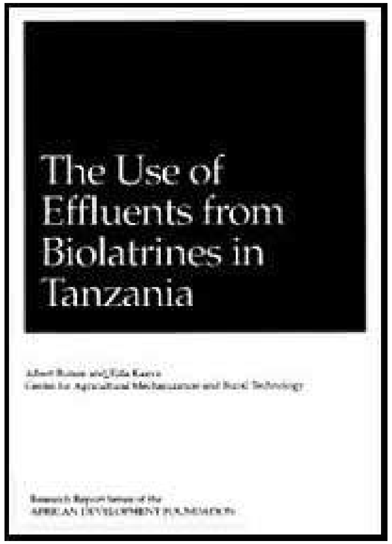


Fertilizer production and usage

The application of human excrete to the land to fertilize crops is an ancient practice, well established in many countries of the Far East, where the fertility of the soil has been maintained by excrete fertilization for over four thousand years. It is the only agricultural use option in areas without sewerage.

In developing countries, the majority of households are without sewerage and are likely to remain so, at least in the foreseeable future. It follows that emphasis should be directed toward the implementation of on-site sanitation systems that readily permit the safe reuse of the digested excrete. The primary example is a biolatrine system with a suitable temperature and sufficient retention time, such as 25°C to 35°C for 150 days.

The most important changes in the fertilizer value of excrete bio-effluents, as compared with fresh excrete, can be considered under three headings:

1. **the ratio of carbon to nitrogen (C/N);**
2. **the content of mineralized nitrogen (Nmin); and**
3. **the biologically harmful effects of excreta.**

Table 4: C/N Ratios for Some Organic Materials

Material	***C:N Ratio***
Poultry Manure	5:1
Human excrete	10:1
Cattle bio-slurry	20:1

Fresh cow dung	25:1
Garden soil	40:1
Straw	70:1
Sawdust	300:1

A substance can only be considered as an N-fertilizer, if the C/N ratio is significantly smaller than that of the soil, i.e., it contains a higher proportion of nitrogen. The range of C/N ratios for some common organic materials can be seen in Table 4.

The values in the table make it clear that one would not add nitrogen to the soil in the form of straw or sawdust. With C/N ratios even greater than ordinary garden soil, they would not add to the proportion of nitrogen content but rather reduce it.

During the generation of biogas, the total amount of nitrogen in the residue stays more or less the same, while carbon is removed in the form of methane and carbon dioxide. The resultant slurry has a lower C/N ratio, and a higher value as a nitrogen fertilizer.

A plant can take in nitrogen only in mineralized form, either as nitrate (NO_3) or as ammonia (NH_3). The Nmin content of excreta and its bio-slurry is composed mainly of NH_3, whereas the Nmin content of soils and compost is mainly NO_3.

In fresh excrete, the Nmin proportion of the total amount of nitrogen is about 30 percent. Thus, about 30 percent of the total nitrogen, in the form of NH_3, is

directly available to plants. In well-digested excrete, the proportion of mineralized nitrogen is doubled. This means that the short-term fertilizing effect is maximized, concomitantly reducing the long-term fertilizing effect. Under tropical conditions in particular, maximizing the short-term effect is more important.

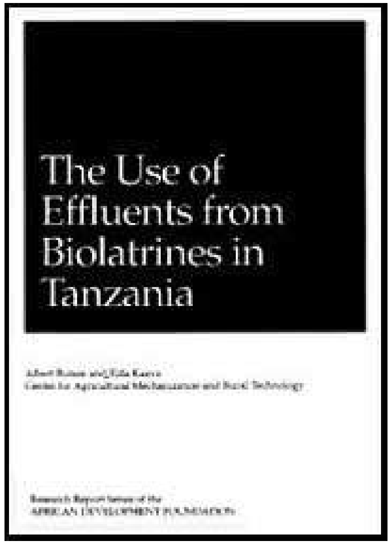
Although fresh excrete as well as bio-digested slurry has a positive fertilizing effect, organic acids in fresh excrete can have a harmful effect on plants and soil organisms by altering the ph value of the soil. This danger, combined with the presence of pathogenic microorganisms, emphasizes the importance of the bio-digestion process.

The slurry produced by biolatrines has a number of advantages for use as a fertilizer. Direct application of liquid fertilizer, covering the soil, conserves both nutrients and moisture. The organic properties improve soil composition and support root growth. Hazards of erosion, as compared with use of artificial fertilizers, are reduced.

The work load can be much less than for an application of artificial fertilizers, particularly when the land topography allows gravity flow distribution through canals and channels. Even when flat land does not allow gravity flow distribution, the effluent can be stored in drying pits, from which it can be drawn in buckets and carried in buckets, wheelbarrows or ox-driven carts to the fields where it is needed. It can also be combined with compost to enhance that process.

Even if one does not optimize the use of biolatrine effluent as a fertilizer, any use at all of properly treated effluent is a net addition to available fertilizer. And it is relatively easy to reduce the risks simply by waiting the appropriate time period

for die-off of pathogens.



Research plan

The analysis presented above revealed several primary obstacles to expanded utilization of effluents from biolatrines as fertilizer. There is inadequate mass

awareness of the technology, resistance to its acceptance due to negative social and cultural attitudes, and lack of serious concern and commitment from government leaders and policy makers.

The assumption underlying this research is that finding ways to overcome these obstacles, and to achieve the wider diffusion both of biolatrine technology and of utilization of effluents as fertilizer, would have significant benefits. These would include increased resource utilization; maximized agricultural and aquacultural yields; expanded harvest time based on diversified products; marketable surplus; energy source substitution through use of biogas; general environmental protection through wood-fuel substitution and improvement by treatment of soil condition; public health improvement by treatment of wastes; and, ultimately, improvement of living standards of the general population.

The objectives of this research were:

1. **To investigate public opinion regarding biolatrine technology in general and, in particular, concerning acceptance of biolatrine effluents for agriculture and aquaculture;**

2. **To establish baseline data on the existence, the nature and content levels of pathogenic microorganisms from general biolatrine influents and effluents, in order to make appropriate recommendations for safe treatment, handling, reuse, or disposal;**

3. **To evaluate the effects of socio-economic factors, socio-cultural aspects, and religious values from different communities in the country on**

acceptance of the technology; and

4. To develop recommendations for community leaders and government policy makers on the best strategy for wider dissemination of the technology.

The research plan to achieve these objectives consisted of several distinct research methodologies. These include establishment of demonstration units for investigation of pathogen die-off in particular as well as for observation of user responses, a questionnaire designed for users and potential users of biolatrine technology, a research visit to Burundi for comparing notes on similar projects there, and pilot public awareness programs in dissemination of the technology.

a. Demonstration Units

Demonstration biolatrine units were installed in several strategic institutions of different types. One was set up in a district hospital in Arusha province. Another was located in a military camp at Oljoro where about one thousand recruits are trained each year. And a third was constructed at a secondary school in Kagera province.

These sites provided specimens for laboratory testing of biolatrine influents and effluents, to determine the content and persistence of pathogens. In each site, moreover, demonstration vegetable gardens were established with root vegetables (such as carrots and onions), leaf vegetables (such as spinach and lettuce) and fruit vegetables (such as tomatoes and paprika).

The gardens were both fertilized and irrigated using effluents from the biolatrines,

in order to provide an empirical test of the effects on plant growth and on the pathogenic content of the plants at the time of maturity.

b. User Questionnaire

To evaluate the attitude of the users and potential users of this technology, the research team, including a sociologist, conducted field visits both to the demonstration sites and to other sites with biolatrine installations. Questionnaires were prepared and used in interviews. More than 60 percent of those interviewed filled out the questionnaires. The views of others were elicited through less formal discussions.

c. Exchange of Experiences with Burundi

A visit was made to Burundi, a neighboring country with climatic conditions, vegetation and social character very similar to those in Tanzania. Burundi has more than 10 years of experience with institutional use of bio-digesters, and it was likely that much could be learned from that experience. The focus during the visit was on the level of general acceptance and utilization of biolatrine effluents, on the strategy adopted towards extension and the factors related to acceptance of the technology, as well as on some technical aspects.

d. Public Awareness Programs

The research took place in the context of, and was coordinated with, ongoing programs to disseminate biolatrine technology. Methods being used include seminars, scientific symposiums, newspapers, radio programs, and discussions with agricultural and livestock extension officers.

Several project proposals to possible donor agencies on installation of biolatrines have been written for private, church and governmental institutions. The selection of beneficiaries was made taking into account not only the institutions' needs for safe handling of waste, but also the extent to which they might serve as demonstrations to others. Involving government officials was essential both for their role in mobilizing public support and for possible financial assistance to promotion of the technology.

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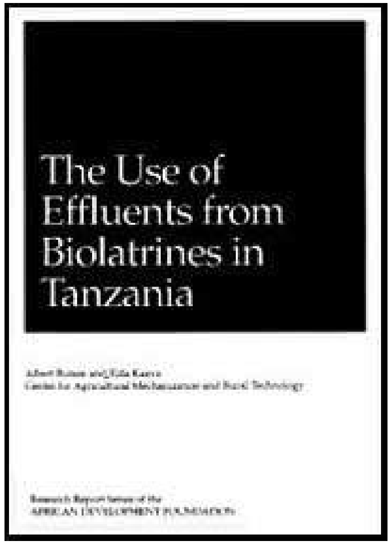

The Use of Effluents from Biolatrines in Tanzania (ADF, 1996, 38 p.)

Research findings and interpretation

I. Demonstration institutions

In addition to units already installed under the regular CAMARTEC program, new units were constructed at Arumeru District Hospital, Oljoro Military National Service Camp, and Rulenge Secondary School. The biolatrine at Arumeru District Hospital has a 30 m³ capacity, with four seats. It is able to handle the wastes of about 200 people with a retention time of 150 days.

Both hospital authorities and patients were grateful for improved toilets. They particularly appreciated the fact that the wastes could be treated safely even without water, a persistent problem they had faced in the past. The effluents are to be used mostly on maize fields.

Oljoro Military National Service Camp, also in Arusha province, had previously acquired, by contract with CAMARTEC, a 50 m³ digester making use of animal waste. This saves about 30 percent of their energy requirements and provides fertilizer in the form of slurry for about three hectares of fodder grass and vegetable gardens. They decided also to install biolatrines, beginning with an 8-seat toilet and 32 m³ digester. One of their objectives was to avoid the cost of clearing their latrines with vacuum suction vehicles from Arusha town.

With the increase in the camp's resident population to about one thousand, the digester proved too small. Although they obtained some gas for lighting and cooking, gas production, as well as usefulness of the effluents, was reduced by short retention times (see Appendices 2 and 3). Under the research grant, there has been progress towards constructing a 50 m³ digester for the purpose of more thorough treatment of the digestants.

Rulenge Secondary School, in Kagera Province, has a total of about 112 m³ of installed biolatrines, with a total of 24 seats. The digesters are connected to the previously installed latrine system, necessitating such a large volume. The school is now saving about 30 percent of the total school energy requirements, and good use is made of the effluents in their gardens. Formerly, untreated effluents were removed manually whenever the latrines got full.

a. Demonstration Results

At these beneficiary institutions, it is immediately clear that the question of technology acceptance is not an issue. The benefits are obvious and appreciated by both managers and residents. The students at Rulenge Secondary School, for example, who will never forget the two terrible days every year spent emptying their former concrete-based latrines, refer to their biolatrines as "Liberation Units."

Tests were conducted at the above sites, at the B.E.S. biolatrine installation, and at other selected sites. In general, the vegetable gardens fertilized and irrigated by use of bio-effluents flourish just as well as any other good garden. The fertilization process was deliberately not carefully controlled: for example, watering of vegetables was continued until the plants were mature, without taking into considering the possible survival of some pathogens. If the results skill turned out safe under such conditions, then the risk would indeed be minimal.

Most of the existing biolatrines had their digestants analyzed to identify pathogens. Analysis was done more than twice in every case after periods of about four months. Specimens were drawn from different levels in the digesters,

in order to sample all possible conditions favorable or unfavorable to pathogenic micro-organisms. Pathogens examined included bacteria (shigella, salmonella, pathogenic E. coli, vibrio cholera), protozoa (entamoeba hystolitica), helminths (ascaris lumbricoides, hookworm, schistosoma, taenia, trichuris trichura) and viruses (enteroviruses). Results showed that the most persistent pathogens were the helminths (intestinal nematodes), particularly the ascaris.

Survival of Ascaris eggs and Salmonella species in soil tends to be longer than the growth period of most vegetable plants. Survival periods of viruses and hookworm eggs may also occasionally be as long as the growth periods of certain vegetable crops. On crop leaves the survival period of excreted pathogens tends to be shorter than the growth period of vegetables.

If such persistent pathogens are present, then one must either prolong the retention time in the biolatrine or use them on crops with longer growth periods, in order to allow sufficient time for them to die off (see Figures 3 and 4).

The results of analysis of the pathogenic content of vegetables grown in effluent-treated soil showed that they needed only normal food preparation processes before consumption just as normal vegetables from the public market. Indeed, tests by the Tanzania Bureau of Standards revealed that spinach from the public market had more coliform bacteria than the bio-effluent treated spinach (see Appendices 5 and 6).

II. User questionnaire

A total of eight provinces and nineteen districts were visited during the course of

the research. In these, twenty-five sites are using biolatrines or have their toilet systems connected to digesters principally fed with animal wastes. Another twenty-two institutions at the visit sites are potential users.

In general, those exposed to the technology, through the CAMARTEC program, were convinced of its usefulness. In comparison to the potential nationwide impact, however, the number reached so far is very small.

The discussion and interviews at the sites visited were accompanied by active mobilization in surrounding areas. Short seminars were conducted in villages, involving village leaders, elders, and women. The response was generally favorable, despite initial doubts.

Given their positive responses, schools and institutions already using the biogas technology were asked to integrate it into their school syllabus.

a. The Research Findings-Questionnaire Feedback

People who were interviewed fell into the following four categories:

1. The village community. Most of them were approached through individual families. Most of these people depend on subsistence farming and a few animals, particularly cows, goats, and pigs.

2. The village and semi-urban middle class families. Most of the semi-urban people are civil servants or in some way employed as teachers or medical assistants, while the village families hold relatively large farms or hold some kind of commercial business.

3. Institutions, including schools, hospitals, prisons and army camps. Both rural and urban based institutions were visited.

4. Village opinion leaders and political leaders.

b. Responses

The Village Community. **Most of these people have pit latrines in their neighborhoods and have to dig another toilet whenever the existing one fills up. Some of these toilets are the old, poor system, some without roofs.**

In some cases, people tend to opt for not using these toilets especially when the toilets are in terrible condition. Some people, particularly the animal keepers, do not have toilets at all.

More than 90 percent of this category responded quite positively to the biolatrine technology. However, their big interest was the possession of a more secure and more hygienic toilet unit, but with little interest on the effluent reuse. The authors noted that the beneficiaries could easily be convinced and directed on the reuse of these effluents once they had these bio-units. The biggest problem these people are facing is that they are really too poor to afford these units, and those with more income had other priorities like sending their children to school, buying more animals and expanding their farmlands.

The Midddle Class**. About 40 percent of people in this category could afford these bio-units. Almost all have formal education which made it easy to understand. However, it is in this category where all sorts of questions were raised, for instance, on the safety of the effluent and which kinds of food crops could be**

fertilized. By the end of the day, the authors found that these people needed more mobilization than what had been provided to them on the installation of demonstration units. Of the 170 people who were interviewed, 42 had agri-bio-units, and their response was positive. About 100 said they liked the idea and would install these units once they had financial capabilities. Most of them asked about the subsidy possibility. The rest simply said they will think about it.

***Institutions*. Administrators of institutions immediately realized the importance of this technology. They have little or no choice as a solution to their existing problems. For example, the Rulenge Secondary School, had toilet bottoms in concrete which were emptied twice a year, manually. Currently Rulenge has seven, 16 cubic meter biolatrines and is already using slurry on its orange trees and has integrated bio-technology in the school syllabi.**

Endavofta Secondary has no pipe water connection or simply no water supply at all. It gets cooling and drinking water from a distance of ten hen brought by tanker. The school receives about one-fifth of what it needs. It used pit latrines as well. There are now two, 30 cubic meter biolatrine digesters with 8 seats. Endavofta Secondary School is a rural school based in Varatu, Mbulu district in Arusha province.

Favalu Secondary School is a girls secondary school which has about 1200 students, 800 of them boarder students. The school is connected to the city water supply system, but the school gets very little water. It buys water which is brought by vehicle and this is only for cooking and very few other requirements. The school has flush toilets, but without water that is as good as no toilets at all. At the time of the interview, students were using standing water from what was

formerly a fishpond. They drew water from this pond by use of buckets to use to flush the waste. The School is based right in the center of the city of Dar-es-Salaam.

Patandi-Arumeru Hospital is a district hospital for West Meru district, Arusha province. Before this hospital got a 30 cubic meter digester with four toilet seats (financed by ADF through this research), it had a small, one-seat pit latrine to serve about 150 people. The latrine was old and damaged such that some people preferred to relieve themselves outside. The whole sanitary situation was terrible.

These are but a few of many visited schools and institutions. The response towards biolatrines was quite positive, though the reuse of bio-effluent was always an issue for discussion. This raised concerns particularly in institutions and schools in Zanzibar where almost 100 percent of the students are Muslims. Again, the general feedback shows that intensified mobilization campaigns with demonstration units are needed. Both need resource inputs.

***Village leaders*. This is a category involving political leaders and community opinion leaders who have influence on the community. It is an important group as the people involved have the means to approach and convince the public. The problem noted here was the direction of the approach. It is not the beneficiaries of the technology (who are the victims) appealing to the government leaders, neither is it the government trying to understand the problem and assist the people, but rather a group of technologists somewhere in between (including the authors of this report) who try to define the problem to the beneficiaries and explain the usefulness of the technology as a solution to their problem. Then the same group explains to the leaders the problem the communities are facing and ways they**

could assist.

To make an impact in both directions, this group needs to be strong in terms of resources (personnel, material) to expose this technology to as many people as possible, as well as working to come up with more concrete facts to convince the government leaders and other donor agencies. The technology is still below the self-sustaining level.

The question of technology affordability is crucial. In all cases, the authors tried to ask the beneficiaries whether, if they got support for the biolatrine units, they would use them. The levels of willingness differed from one family to another, depending on the family economic potential, and from one institution to another

TOMATO GARDEN WHICH WAS FERTILIZED USING BIO-EFFLUENT.

III. Exchange of experiences with Burundi

The government of Burundi realizing the importance of bio-technology, initially supported several schools and colleges in installation of institutional digesters for

treating excrete as well as kitchen wastes. In Burundi a small country with relatively easy communication links, better road networks than Tanzania, and extensive television and radio services, technology advertisement and mobilization of people was relatively easy. Individuals adopted the technology very quickly. Acceptability of the technology was not very difficult, and utilization of bio-effluents has been quickly integrated into farm systems.

Bio-technology in Burundi received good support from the government after the following events:

1. **A study carried out in the late 1980s proved that out of fifty-one randomly selected institutions, thirty-seven had their septic tanks not functioning due to blockages and/or lack of emptying facilities.**

2. **According to environmental policy in Burundi each institution, factory, or industry must treat its waste water before it goes into a common purifying plant (for the area with such facilities - as many other rural areas have none). In that sense, following the problem explained above, anaerobic waste treatment through bio-digesters which provided gas for energy purposes was a better alternative to septic tanks, particularly for the semi-urban and rural sectors.**

3. **About the same time one "Bureau des Projets d'Education" (B.P.E.), a state owned organization, compared the investment costs for waste treatment for 400 users by septic tanks and biogas plants. This showed that the bio-treatment plants were about US$5000 less expensive than septic tanks.**

FERTILIZATION OF TOMATO GARDEN AT NYANKANDA SECONDARY SCHOOL IN BURUNDI

The major impetus for extension of this technology was due to serious government involvement, either through direct support or through several donor agencies.

Tomato garden fertilization with bio-effluents is done manually, even with ungloved hands at Nyankanda Secondary School, Ruyigi province as well as banana and coffee fertilization with effluents at Makamba Teachers College in Makamba province.

Interviews and discussions in Burundi with more than eighty people from eleven provinces, including users as well as potential users, revealed consistently positive attitudes towards this technology. The only problem cited was shortage of funds for users to expand or rehabilitate existing units, or for would-be users to acquire new units.

Special Energy Programme Burundi, the agency responsible for this technology in the country, was formerly foreign-supported. Now largely self-sustaining, it is optimistic about wider dissemination of this technology in the country.

IV. Public awareness programs in Tanzania

Tanzania, in contrast to Burundi, encountered several hurdles in the process of technology dissemination. In relative terms, Tanzania is about 33 times the size of Burundi (about 945,000 square kilometers/28,000 square kilometers) and its population is about 5 fumes the population of Burundi (27 million/5.5 million). The country's poor infrastructure system makes it even more difficult to reach many people easily.

During the course of the research, CAMARTEC continued with its public awareness programs designed to popularize biogas technology. CAMARTEC personnel, including the authors of this paper, participated in efforts to publicize the technology through media such as newspaper, radio programs, relevant seminars, workshops, and scientific symposia. Whenever a new region or district is visited, regional and district leaders are contacted to ensure their support. Representatives of the section for women and children, in the Ministry of Community Development, are consistently supportive. Regional and district field and extension offices in agriculture, health, and livestock have been involved, particularly in selection of appropriate demonstration sites as well as in general sensitization campaigns.

Often it is not difficult to explain the need. This picture, for example, shows a flood of waste water from the municipal sanitation system in Arusha. In the same area,

there was an outbreak of cholera only two months previously. The municipal authorities needed little convincing of the necessity for a solution such as biolatrine technology. The issue is rather how to find the resources for its construction.

The research team, as part of the fulfillment of the research goal, had on two occasions successfully disseminated the research findings.

The first occasion was through a conference held in Benin, West Africa where more than 150 attended. The conference participants constituted all categories of people, from university professors down to secondary school teachers, renowned scientists and researchers down to technicians, and some big institutions down to villagers who are involved in appropriate technology promotions.

The conference was so convinced of CAMARTEC's research recommendations that these recommendations were included in the final conference resolutions. This conference was organized and financed by the African Development Foundation (ADF).

The second occasion was through a two-day seminar in Arusha, Tanzania where the seminar objective was to expose the research results to people. The seminar participants included key people from relevant ministries like the Ministry of Education, Health, Community Development, Women and Children, Environment, Defense, the previous officers, some representatives from resident donor agencies, schools, hospitals, and other institutions. Potential beneficiaries were also united. Journalists from different news media also participated. The conference was officiated by the regional leaders.

The seminar resolutions included the realization of the importance of bio-slurry recycling as an appropriate option for most of the developing world and what remained was for each individual agency to play its role accordingly to promote this technology.

FLOOD OF WASTE WATER IN ARUSHA.