Alto Beni (D.A.B.), Bolivia

Sector: DRINKING WATER SUPPLY and SANITATION

Working Paper No. 5

TECHNICAL ASPECTS

REPORT

by: Karl Wehrle, SKAT, St. Gallen

for: COTESU (DEH/SDC), La Paz, Bolivia

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SKAT

Varnbüelstraße 14, CH-9000 St.Gallen, Switzerland, Tel. 071 23 34 81

SKAT
Schweizerische Kontaktstelle für Angepaßte Technik am ILE, Institut für Lateinamerikaforschung und Entwicklungs-zusammenarbeit an der Hochschule St.Gallen

SKAT
Swiss Center for Appropriate Technology at ILE, Institute for Latin-American Research and for Development Co-operation, University of Saint-Gall

SKAT
Centre Suisse pour la Technologie Appropriée à l'ILE, Institut de Recherche sur l'Amérique Latine et de Coopération au Développement, Université de Saint-Gall

SKAT
Centro Suizo de Tecnología Apropiada en el ILE, Instituto de Investigación sobre América La de Cooperación al Desarrollo, Universidad

Content

page

Content of Annexes

1. Introduction

This technical paper is to be considered as part five of the following series of working papers

1. Proposal for the organisation and time schedule of the planning phase (incl. comparison of various options)
2. Job describtions and qualifications for the project staff required
3. Micro-projects (Pilot-Projects)
4. BID-contribution to the sector Saneamiento básico

Aim of this paper is not to provide a complete perfect prescriptions for projectsolutions rather then to place the technical component at its relevant position within the complexity of the programme of saneamiento básico and secondly to provide useful hints to find ways and means for appropriate solutions.

Moreover who-ever consults this paper has to keep in mind that it has been prepared with limited knowledge of the actual site circumstances. Hence a critical mind is required to adapt any of the proposals to the local conditions.

In case of a particular problem which requires more detailed informations relevant literature (comp. list of references) or the author of this paper may be consulted.

2. Objective of the programme saneamiento básico

Failures and mistakes concerning technical solutions origine mostly from overemphasising the technic but neglecting the original objective of the projects and programmes. That's why the planners, decision makers, technicians (incl. myself) as well as the beneficiaries are reminded with some keywords to be and keep aware of the objectives of the programme:

- The starting point of any project has to correspond with the basic need of the target group (awarness of target group, communication to planners and technicians)
- Health improvement and easier access to drinking water may be the primary aim of above programme. But it has to be kept in mind that the longterm objectives of the integrated Alto Beni programme (incl. protection of ecology by adequate production methods) require the building up of increased confidence of the population into the programmes initiated.
- Thats why the concept of the project has to consider the importance of the self help aspect as follows:
  - . participation of target group in planning stage
  - . clear definition of the goals of the project
  - . education on health and hygiene has to be commenced before any other project activities. [Health and hygiene education - the software component of the project - has to be given the same attention financially and staffwise than to the hardware (pipes, taps, pumps etc.) during the project realization as well as to follow up programmes.]
  - . transparently and clearly structured proceedings of the project
  - . adapting an appropriate and accepted method and technic for the project realization (including organization, designe, material, workmanship etc.).

. practical participation of the target group at the highest possible level during project realization (organization, contribution of labour, material event. financials etc.)

. the project staff has to support sensitively and complementary the self help activities of the target group

. the time schedule has to be flexible and adapted to the readiness for participation

. appropriate training of local personal has to be emphasized in particular in the view of selfreliance in follow up programmes etc.

- Reflection on the progress of the programme including adequate modifications have to be kept as a continuous policy
- Continuity of capable and qualified project staff at all levels is an absolut requirement to bring the programme to the expected success.
- Operation and maintenance of any project should not cause any unbearable load both financially and of skilled personnel.

New settlements ⟶ development of new land ⟶ Cutting down of black forest for agricultur at steep hill sides: ⟶ eriosion ⟶ loss of valuable soil ⟶ loss of forest ⟶ permanent desert

3. Health Aspect

3.1. Actual situation worldwide and lessons to be learnt

"The safe water supplied from a tap or the spout of a handpump is only as clean as the cupped hand of the person who drinks it! Hence the simple installation of protected intakes, treatement-stations, pipes, pumps and latrines will not automatically improve people's health. National governments have invested millions of dollars in the hardware, but almost no effort has gone into health and hygiene education - the software component of any water and sanitation programm. Diarrhoea, caused by polluted water, continues to kill 40 million children each year. Despite the worldwide multimillion dollar effort into the hardware the health impact is very limited." - This is the

Photo: UNICEF/T. S. Satyan

..... water is only as clean as the cupped hand of the person who drinks it.........

introductionary statement of Sumi Krishna's artical in Waterlines Vol. 3 No. 4, 85 (comp. Ref. [3]) - He continues and reports about a comperative study on the effectiveness of health improvements which has been recently undertaken in villages in Bangladesh. The study villages were provided with handpumps, latrines and even hygiene education whereas the control villages received no such facilities. After four years, the results of the weekly diarrhoeal surveys, and monitoring the growth of children, showed that the study villagers were not markedly healthier - despite the hardware and education!

This is certainly disappointing if not to say disencouraging. But the lesson to be learnt from above results is that the software is at least as important as the hardware. Behaviour of people all over changes slowly, especially so when people are not convinced about the effectiveness of the measures for improvement. That's why the software component of a programme cannot be shot like a bullet at a target audience. Health education requires a much greater receptivity to the villagers'own pereceptions of their basic human needs, and of the benefits of improved watersupply and sanitation. In the health education field there is also a great need to explore the different means of communicating informations. Changes in hygiene behaviour can and do, occur in a varriety of other ways than person-to-person contact. (Comp. Ref. [3] and [4]).

3.2. Consequences for D.A.B.

First of all it is important that the planners and decision makers consider above results seriousely. It would be irresponsable to assume that the context in Alto Beni would be as different that the software could be given in this case second priority. Once more, if only taps, pumps and latrines are provided without the software, this will be attractive only for the short term. But if the goal is to build up confidence of the population to improve their living in the longterm the software component has to be considered seriously and given the same attention than to the hardware - the technology.

The backbone of any health programme is certainly the qualification of the personnel, who is involved in. Careful selection of the personnel, considering not only the level of knowledge in the health component but also the capability and sensitivity to communicate the message, is therefore the precondition to commence the programme. Adequate support both morally and financially of the software component has to be followed up throughout the realization of the programme.

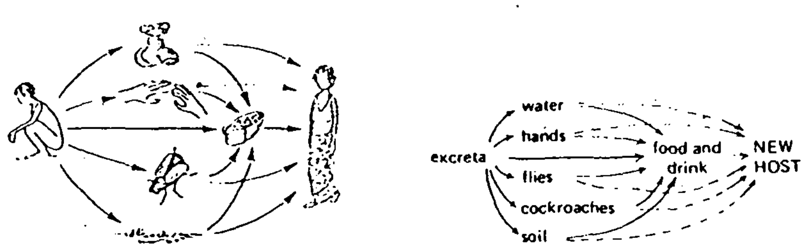
3.3. Content and method of Health- and Hygiene-Education Programme

The required content and the appropriate method of the health- and hygiene-education programme have to be learned from careful evaluations of the actual situation.

The keywords and sketch below may provide a quick overlook of the software component:

a) The Content:

- information about waterreleated diseases incl. their effects
- education about the transmission paths of waterrelated diseases



Faecal-oral route of disease transmission

Man is unfortunately the main reservoir of most of the deseases that make him sick!

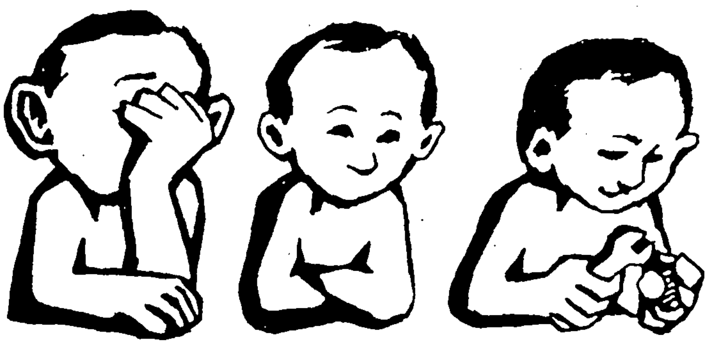
- information about ways and means to blockade transmission paths.
- information and education about possible preventive measures:
  . personal hygiene
  . domestic and general hygiene
  . improvement and protection of drinking water source (role of quality, quantity, accessibility)
  . treatment of contaminated water (boiling, traditional methods, comp. chapt. 8.8.2.)
- information and training about curative measures
  . oral rehydration therapy
  . etc.
- underlining the importance of maintenance to get at longterm benefits.

b) The Methods:

- person-to-person contact (e.g. health worker)
- clinic days (remember: a suffering person is more receptive to learn about preventive measures)
- comics, film-strips, flipp charts
- popularising improved behaviours e.g. imitating screen heroes or the Coca-Cola effect etc.

The required detailed informations both for the content and methods are available from relevant literatur (comp. Ref [4] + [5]) as well as from various institutions to be found in La Paz and in nearbouring states (comp. Ref. [6]). Though these informations will still require skillful adaption to the context of Alto Beni this paper will not provide any further detail on the subject.

Learning by doing:



"hear and forget............see and remember..............do and understand"

4. Modern ways and means to find the appropriate technical solution

4.1. State of art

Million of dollars have been invested in the hardware and failures occured not only because the software was neglected but also because the technology choosen was in-appropriate. The hundred of thousands abandoned handpumps all over the world, the broken down catchments, dry-running taps etc. speak for themselves. These facts have been realized by many institutions, governments and individuals. In its consequence modern ways and means to find the appropriate technical solutions have been and are developed.

4.2. Factors which determine the appropriateness of a technology

A technology must be appropriate in the following terms; which are listed in order of importance:

- in performance so that it does the job required
- in quality of material and construction so that it requires the least maintenance and guarantees the longest service life
- in cost so that it can be afforded
- in required operation and maintenance so that it can be done with the local skill available and financed by local resources
- in considering local resources both material and skill so that money can be invested locally
- in considering the self help aspect so that selfreliance can be achieved to a high degree
- in considering the social and cultural implications so that the quality of living is not reduced
- in considering local acceptance so that the technology is brought into use.

4.3. Modern ways and means to find the appropriate technical solution

Most cases of inappropriate technology arise from the unquestioning export of the technologies from Europe and North America to the developing countries. Good engineering involves the sensitive application of basic principles to a particular problem so that a solution is derived which is genuinely appropriate to the local context as described above. While the basic principles can be learned from relevant literature the understanding of the local context requires a careful study of the local history. Therefore it is adviseable to study at first the way villagers solve a particular probleme with the means, preferences and beliefs they have. The historical background and experiences should be understood before any modifications are suggested.

The designing engineer should keep in mind if he has to blame failures, breakdowns etc. on poor standards in workmanship or shortage of skilled and supervisory staff, it is like a workman blaming his tool. Appropriate engineering requires designs which can be made and kept to work, with the labour, materials, financials and organisation currently available.

In case planners, decision makers, politicians etc. request an advanced but in the particular case inappropriate technology, they have to be clearly confronted with the consequences (e.g. problems to cover the cost for operation and maintenance).

4.4. Consequences for D.A.B.

Fortunately the situation in Alto Beni area is such that village water supplies with different service standards are already in operation. That's why it is most essential in a first step to evaluate the actual situation in different standard villages.

The following steps have to be undertaken to find the appropirate technology:

1) Conduct a survey according to Ref. [7] and chapt. 6

2) Evaluate and analyse the results according to criterias provided in chapt. 4.2.

3) Find out the appropriate technology in considering sensitively
   a) the basic principles of the technology (comp. chapt. 5., 7., 8.)
   b) the local context.

It is highly recommended that above evaluation is undertaken in particular in those villages which have already a kind of drinking watersupply or some sanitation facilities before any new scheme is commenced.

POLICY OF MODERN ENGINEERING:

- LEARN FROM THE VILLAGERS who have a historical experience of the particular local context
- LEARN FROM EXISTING PROJECTS who present successes and failures
- INCORPORATE ABOVE FINDINGS WITH THE KNOWLEDGE OF THE BASIC PRINCIPLES OF THE PARTICULAR TECHNOLOGY

Traditional Workmanship = Excellent Engineering

Temporary yard-connection with hose-pipe:
An indication for personal initiative! At such places the programme has to be sensitively begun namely by promoting such initiatives

5. Water Quality, Quantity and Accessibility

In order to understand the role and importance in health improvement of water quality, quantity and accessibility the transmission paths of water releated diseases have to be know. Since brief information about transmission paths have been provided already in chapter 3.3 together with hints on relevant literatur only some conclusion of the to date findings are summarized below.

Whereas in the past decades most emphasis has been paied to improve the waterquality recent evaluations have given evidence that the more water is available close to places of use the more efficient the health improvement. This becomes understandable when the fact is considered that most of the waterborne diseases (transmitted by drinking) fall also in the categorie of water-washed diseases (tansmitted by hands, food etc.). For the same reason the importance of hygenical excreta disposed and hygieneducation becomes obvious comp. chapt. 11.

The aim of any water supply has to be to provide water of safe quality in sufficient quantity as close to the consumer as possible. What this statement implies for these three parameters in special is shown below.

5.1. Water Quality (comp. Ref. 8)

5.1.1. Definition of acceptable standard

The standard of drinking water quality should be such that it can be consumed by people without any danger to health but for refreshment and pleasure yet local rural people with different backgrounds culturs and beliefs have often completly different views about good waterquality then what western science claims to be safe quality.

- On one hand scientists define water quality solely according to its physical, chemical and biological properties.
- On the other hand local people consider water still as an important live-giving entiety of the cosmos. As such it is highly respected and plays often an important role in religious cermonies. E.g. There are traditional beliefs which state that a well should not be covered so that the sunlight can shine into the water and enriche it with vital force.

It is not the place here to discuss the two extreme positions but the scientists must respect that water can not be reduced entirely to an instrumental thing as well as the local people have to accept that the environment has changed in a way that the load of pollution has become much more intense than in the past. Reasons for this changes may come from increase of population, more travelling and accordingly increase of transmission of new pathogenic (disease causing) organism as well as more intensive and expansive agriculture incl. agro-chemicals and reduction of forest areas etc.

Though it might be considered as only part of the entire reality, practical experiences with the present scientific methods of defining safe waterquality has proven that health improvement is the consequence when it is strictly applied. Accordingly a standard of safe quality incl. critical levels of concentrations has been proposed by WHO "Guidelines for Drinking-Water-Quality" Ref. [23] If the government of Bolivia has laied down national regulations they are to be considered in the first instance.

5.1.2. Parameters to be analysed

a) Suitability for human consumption

Aim of a drinking water analysis is first of all to find out wether it is suitable for human consumption without any danger to health. According to the health hazards which must be expected water needs to be analysed in the following three aspects:

- bacteriological (contamination by faecal material)
- chemical (contamination by toxic material or indication of any other pollution)
- physical (contamination by unpleasent material)

b) <u>Suitability for construction material and smooth operation</u>

Water can be very aggressive towards certain building materials and shorten significantly the service life of construction even so when the same water is not dangerous to health. That's why the water needs also to be assesed towards the following aspects

- chemical (e.g. aggressivity towards cementous material: relation of hardness to free carbon dioxide etc.)
- physical (pH, turbidity, conductivity etc.)

Ref. [8] suggests the specific parameters to be analyzed most essentially.

5.1.3. Ways, methods and means to assess water quality

Different ways, methods and means can be applied to assess water-quality. In any case it is advisable not to relay solely on strict wateranalysis but also to investigate in a more pragmatic way the origin of a source or groundwater and to examine the intake area after potential sources of pollution.

For the practioner in the field it is often not very easy to apply advanced methods to assess the waterquality of a particular source. Especially for a preliminary survey more simple methods may be looked for in particular so, if no other sources are available as alternatives.

Simple methods by attentative site observation are shown at annex IV.

Field tests with simple equipment are discussed in detail at Ref. [8].

5.14. Field test equipment recommended for D.A.B.

Beside the simple site observations suggested above it is essential to apply some test equipment to undertake relevant field assessment of water quality. Comparision of various equipments has been done at Ref. [8]. Though this comparision may not be complete the following equipments are recommended for D.A.B.

Make of text kit	parameters analysed	cost ca.
a) Del Agua (excl. test kit for pH and chlorine)	bacteriological, turbidity, conductivity, temperature	1000 $
b) Hach's combination test kit Model AL-36DT sublemented with c) + d)	acidity, alkalinity, carbon dioxide, dissolved oxygen hardness and pH	300 $
c) Hach's reagents and required colour disks to the comparator of 1 b)	nitrate, nitrite, ammonia	150 $
d) Hach's titiator cartridge No 14395-01 incl. required reagents	chlorine	50 $
cost total approximative		1500 $

Adresses of manufacturers:

Del Agua
P.O. Box 92
Guildford GU2 5TQ
England

Hach Chemical Co
P.O. Box 389
Loveland
Colorado 80539
USA

Hach
Casa Bernardo SA
Casilla 685
La Paz
Bolivia

5.1.5. Personel required to undertake field tests

There is no specialized personel required to undertake the simple field tests suggested above. But the technician who is about to carry out the field tests requires some particular training as suggested at Ref. [8].

5.2. Quantity

5.2.1. Water consumption

Depending on climate and work load, the human body needs about 3 - 10 litres of water per day for normal functioning. Part of this water is derived from food. The use of water for food preparation and cooking is relatively constant. The amount of water used for other purposes varies widely, and is greatly influenced by the type and availability of the water supply. Factors influencing the use of water are cultural habits, pattern and standard of living, whether the water is charged for, and the cost and quality of the water.

Water use and consumption data are frequently expressed in litres per capita (head) per day (l.c.d.).

In the table below typical domestic water usage. Data are listed for different types of water supply systems.

Typical domestic water usage

Type of Water Supply	Typical Water Consumption (litres/capita/day)	Range (litres/capita/day)
Communal water point (e.g. village well, public standpost)		
- at considerable distance (> 1000 m)	7	5 - 10
- at medium distance (500 - 1000 m)	12	10 - 15
Village well		
walking distance < 250 m	20	15 - 25
Communal standpipe		
walking distance < 250 m	30	20 - 50
Yard connection		
(tap placed in house-yard)	40	20 - 80
House connection		
- single tap	50	30 - 60
- multiple tap	150	70 - 250

Since no specific datas about water consumption in D.A.B. are available the figures given below the heading of typical water consumption may be considered for a particular system of water supply (e.g. yard connection 40 l.c.d.).

In case water from the community water supply is also used for other then domestic purposes additional amounts of water need to be provided. The table below gives indicatives datas.

Various water requirements

Category	Typical Water Use
- Schools	
. Day Schools	15 - 30 l/day per pupil
. Boarding Schools	90 - 140 l/day per pupil
- Hospitals	
(with laundry facilities)	220 - 300 l/day per bed
- Hostels	80 - 120 l/day per resident
- Restaurants	65 - 90 l/day per seat
- Mosques	25 - 40 l/day per visitor
- Cinema Houses	10 - 15 l/day per seat
- Offices	25 - 40 l/day per person
- Railway and Bus Stations	15 - 20 l/day per user
- Livestock	
. Cattle	25 - 35 l/day per head
. Horses and Mules	20 - 25 l/day per head
. Sheep	15 - 25 l/day per head
. Pigs	10 - 15 l/day per head
- Poultry	
. Chicken	15 - 25 l/day per 100

5.2.2. Designe Quantity: Quantity to be considered for futur demand

To allow for futur population growth and a higher consumption of water per capita and day, a community water supply has to be designed with sufficient surplus capacity. Since Alto Beni area is developed by new settlements, population growth may be difficult to predict. It is adviseable to treate each settlement separate and to assume a "population growth factor" which is to be expected after the designe periode. The designe periode to be considered is recommended with 25 years. The "population growth factor" may be read from the table below.

Population growth factor

Design period (years)	Yearly growth rate 2 %	3 %	4 %	5 %
10	1.22	1.34	1.48	1.63
15	1.35	1.56	1.80	2.08
20	1.49	1.81	2.19	2.65

The figures above may be considered as a guideline but the estimates need to be evaluated with considering actual experiences in similar cases in Alto Beni area.

Example of estimation of designe quantity:

A nucleo with actual population of 250 capitas and an average yearly population growth rate of approximative 3 % (7 heads) is to be supplied with water. The population growth factor after a designe periode of 25 years reads from the table with ca. 2,0. Hence the futur population to be considered amounts to 2 x 250 = 500 capitas. Though only communial standpipes are provided at present, yard connection may be forseen for the futur. Hence the designe quantity will amount to 500 capitas x 40 litres/cap./day = 20'000 litres/day.

A community water supply system should also be able to cater for the maximum hourly or peak demand during the day (see chapt. 8.5)

5.2.3. Measuring of Water Quantity yielding from a Source

Gauging should be done regularly once a week for more than one year if possible. If only one year measuring is possible, it is a necessity to measure the water quantity of the source as well as the rainfall. Compare the measured rainfall with available rainfall statistics over a long period, which helps to determine whether it is a dry or wet year. This enables to decide if the water quantity will be sufficient. In case of a river, measurement should be taken in the morning as well as in the afternoon (morning: afternoon = 1 : 0.8).

- Measuring Water Quantities with a bucket and a watch

  In most cases of D.A.B. water quantity measuring with a bucket and a watch will be most appropriate. This is an easy and exact method for quantities up to 300 (600) l/min.

  Procedure:

  . One or more pipes, depending on the quantity, are fitted into a temporair earthdam so that all the water passes through the pipes.

  . The flow from one pipe should not exceed a quantity which fills a bucket in less than 3 seconds.

  . Calculate the volume of the bucket if it is not a graduated one.

  . Gauge the flow of each pipe three times and enter the results into the records.

  . Calculate the quantity in l/min. or l/sec.

- Other Methods

  Flow measurments with a weir e.g. Thompson weir are described at Ref. [1] p. 37-39.

5.2.4. Comparision of Designe Quantity to Quantity available from a specific source

The designe capacity of a water supply system is determined by the possible coverage resulting from the comparision of designe quantity (futur demand) with the quantity available from a source. The examples below show different possibilities:

- source yields more then designe quantity
  → system is to be calculated on designe quantity

- source yields less then designe quantity
  . additional sources are available and can cover the designe quantity
    → system is to be calculated on designe quantity

. no additional sources are available, hence designe quantity can not be covered

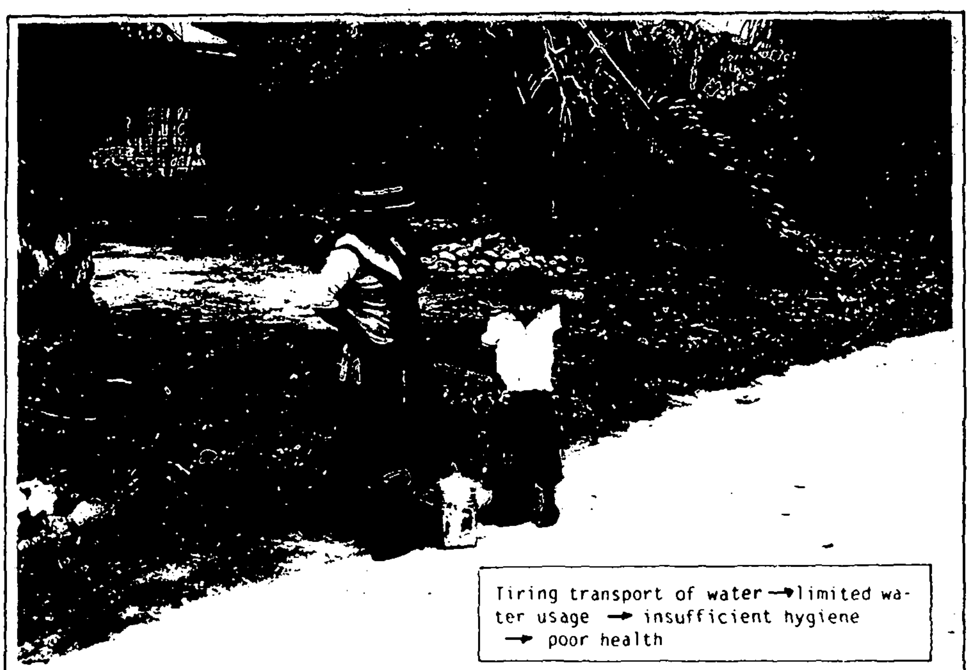
→ assumed designe quantity needs to be reduced by lowering the standard e.g. no house connections etc. → system is to be calculated on the quantity available from the source.

(compare also Ref. [1] p. 52-54)

5.3. Accessibility (compare chapter 8.7)

As already discussed above accesse to driking water should be provided to the best possible convience of the consumers.

- Yard (individual connections are recommended for D.A.B. wherever sufficient water and financial resources are available.
- In case public standpipes are installed they should be placed in such a way that the maximum walking distance for any of the households does not exceed 100 to 150 m.
- Public washplaces for clothes and shower houses may be provided, if sufficient water is available and no natural bathing facilities are at hand. These facilities may be placed further apart (e.g. each third standpipe combined with a washplace).



Tiring transport of water → limited water usage → insufficient hygiene → poor health

6. Preliminary Survey / Feasibility Study

6.1. Development and course of survey

Upon a request for an improvement of the drinking water situation by the villagers concerned a preliminary survey is to be undertaken. In a first step it has to be decided in which category the village in question falls e.g. nucleo with an unsatisfactory existing watersupply scheme or dispersed settlement without any safe supply etc. Then the survey should be conducted according to a well prepared checklist. It is essential not to undertake the technical (hardware) survey separate from social-cultural (software) asepct. This means in practice that technicians, social and health personnel have to work hand in hand.

6.2. Checklist

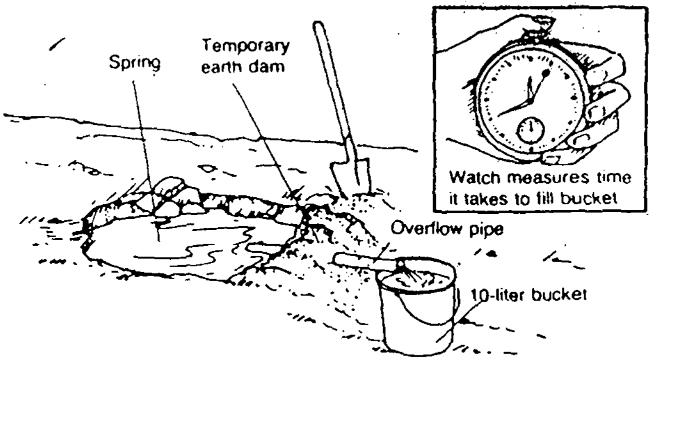
A detailed proposal for a checklist has already been handed to the project authorities in August 84 (Ref. [7]). It is up to the project personnel to adapt this checklists to the actual categories of settlements and local site conditions. It has to be emphasized that a careful preparation of a checklist will be most useful because it will not only serve as a reminder for a complete survey but also as a guideline to introduce the learning process which is the aim of the project.

6.3. The technical part of the field work

6.3.1. Water Supply

Ref. [1] gives profound informations about the most practicable technics to be applied to get at the technical informations which are required for the selection of the most appropriate supply system. Preferences and criterias for selection are provided in chapter 7. The main aspects of the field works are in the following summarized.

- Tracing of Source: (Ref. [1] page 17, 18 + 35)
  - investigate sources which are used at present
  - look for springs (e.g. follow streams to rising point, ask villagers etc.)
  - investigate intake area for possible contamination
- Yield of Source: (Ref. [1] p. 35-39)
  - measuring with a bucket and a watch will be appropriate in most cases. It has to be noted that the information about the minimal yield of a source is of main interest. That's why any source has to be gauged over a periode of time in particular at the peak of dry seasons.



Measuring Spring Flow

- Quality of Source: (Ref. [1] p. 40 + 41)

  Thourough information on waterexamination can be got from Ref. [8].

  Simple methods by attentative site observation are shown at annex IV. If they are supplemented by careful investigation of the intake area, this investigations may be sufficient for the time being - in particular so, if no other sources are available as alternatives.

- Calculation of required quantity and balance of water

  The specific consumption per head and per day has been suggested in chapter 5. This figure is to be multiplied with the expected population for which the scheme is to be designed (comp. chapt. 5). The figure resulting from this calculation presents the daily demand which is to be compared with the daily yield of the source available. Some examples are shown at Ref. [1] p. 52-54. It is essential to do a rough calculation in the field to get an idea about the flow required and the feasibilities to satisfy the required demand.

- Field investigations required for the lay out

  . A rough map of the area including the source with its distance to the village needs to be drawn to scale. The method to draw this map may be from aireal photographs if available or simply with a compass and measuring tape or wheel.

  . Most important is to have informations about the relative difference of hight between the following points: source, proposed site for storage tank, highest and lowest point in the village. Altimeter readings are most appropriate. Generally a pocket-altimeter should be sufficient in accurancy (± 10m), in case of minimal differences a case-altimeter may be required (± 0,5m). Altimeter-readings may be confirmed by measuring the gradients with a clinometer and calculating the respective differences of hights in considering the distances.

6.3.2. Laterines (comp. chapt. 11)

Ref [2] gives useful informations about the ways and means to find the most appropriate solution. The critical point in selecting the appropriate laterine-system is more then anything else the local acceptance. That's why the preliminary survey will consist mainly of the following works:

- investigate the system which is applied at present
- find out the preferences villagers have into this system (men, women, children)
- evalute the designe from the technical and hygenical point of view (durability, fly-avoidance, smell, contact-possibilities etc.)

6.4. Personel required

1 Animator (Social/Health-worker) event. 2 persons

1 Technician

(Qualifications see working paper No 2)

6.5. Survey equipment required

1 compass

1 clinometer

1 altimeter (pocket type or case-type)

1 tape (event. measuring wheel)

1 test kit for chemical wateranalysis *)

1 test kit for bacteriological wateranalysis *)

*) compare Ref. [8]

(watch from which the seconds can be read and a container with known capacity are required for waterquantity measurements)

6.6. Analysis of survey / feasibility study

The findings of the preliminary survey need to be carefully analysed. The following two main aspects need to be evaluated with the same attention and importance:

- software component:
  . level of awarness of villagers → health education
  . felt need and priorities by villagers → other preferences
  . readiness for participation → organisation, education
  . legal rights for tapping water and introducing a protection zone →
  . readiness for operation and maintenance → organisation, financial

- hardware component:
  . health condition → improvement drinking water
  → " excreta disposal
  → " hygiene
  . available sources → quality-, quantity- or accessibility improvement (selection of system see 7)
  . local workmanship → construction method and building-material
  . construction cost → economical considerations, financial resources

As a strategie (mainly to make the software work) the ball should always be handed back to the villagers. E.g. the villagers should be asked after a first contact to clear the possible intake, gauge the yield of the source over a periode of time or to suggeste a designe for a laterin etc. In this way the level of awarness and readiness for participation can be best evaluated.

It is obvious that a preliminary survey is not simply an act of one project visite it is rather a continuous process which includes a good portion of learning to all concerned with and which leads ultimately to the implementation stage.

If the analysis of a particular project is positive the adequate system is to be selected. In case of a drinking watersupply chapter 7 or in case of a laterine project chapter 11 is to be consulted.

7. Selection of Water Supply System (Layout)

After the preliminary survey has been conducted and in its conclusion it is decided that a particular village is ready according to the criterias of chapt. 6.3 to realize a village water supply scheme, the most adequate supply system needs to be selected.

The criterias for selection are directed by two main aspects:

1) The watersupply scheme should do its job under the existing construction conditions

2) It should continue its service under the prevailing maintenance conditions.

7.1. Sources of Water

Because of the unreliability of treatment plants under most rural conditions, the best sources of water are those which do not need treatment.

7.1.1. Groundwater

Groundwater is normally of most reliable quality because it is purified by the filtering action of the soil through which it flows. Therefore it is normally preferable to surface waters.

(1) Springs: Where the groundwater emerges to the surface without artifical help, we speak of springs. When they are situated above the village and have a reliable flow (to be gauged at the peak of dry season) they make the most ideal source for a community watersupply.

(2) Wells: When the groundwater needs to be lifted to the surface it has to be developed by a well. Though devices to lift the water (e.g. handpumps) require frequent maintenance these sources of reliable quality are normally to be prefered to any surface water.

7.1.2. Surface water

Surface water may be readily available and easy to abstract but it is typically very polluted.

(3) Streams: In some sparsely populated areas, streams may be for the time being of a quality good enough for domestic use. But they can never be considered as safe and are subjected for faecal pollution as futur developments may come up in the intake are.

(4) Rainwater: Reasonably pure rainwater can be collected from house roofs made of tiles, slates, (corrugated) galvanised iron, aluminium or fibre-concrete sheeting. Thatched or lead roofs are not suitable because of health hazards. The anual rainfall patterns determine the capacity of the required storage tanks, which may be rather costly to guarantee a supply all year round.

7.2. Supply Systems (comp. Tabel 1)

Many of the potential health benefits from rural water supplies come from an increased use of water as it has been discussed in previous chapters. There is therefore good reason for designing a supply system in such a way that water is supplied as near as possible to the houses as to encourage the maximum possible water use, particularly for hygiene. Ideally water should be provided near each house. Availability of water and cost will determine as how far such an ideal distribution may be realized.

(1) Supply by gravity from a spring: If the flow of the spring is sufficient all year round, this system makes the most ideal village water supply.

(2) Supply from wells: If no springs are available with sufficient flow from above the village but groundwater can be extracted from wells this system may be choosen. This system is as more efficient as closer the wells can be situated to the houses. Attention to the construction of laterines (comp. chapt. 11).

(3) Supply from a spring below the village:

(3a) Waterpoint: In case the only spring available is situated below the village, a waterpoint may be constructed at this place to collect the water safely and increase the availability of water by collecting the flow during time of no consumption (night) in a storage tank.

(3b) Supply from a spring by a hydraulic ram: In case the spring situated below the village yields water in excess the surplus water may be used to drive a hydraulic ram to raise the water to a storage tank above the village.

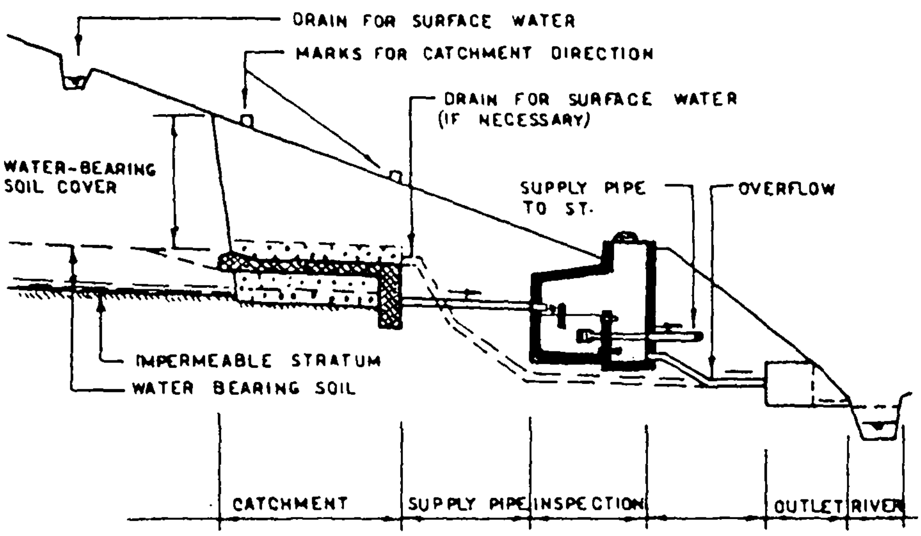
(4) Supply by gravity from a stream: In case no groundwater neither from a spring nor a well is available water may be drawn from a stream. The amount of actual pollution may determine about the immediate necessity for treatement. In any case provision should be foreseen for futur installation of an adequate treatement station.

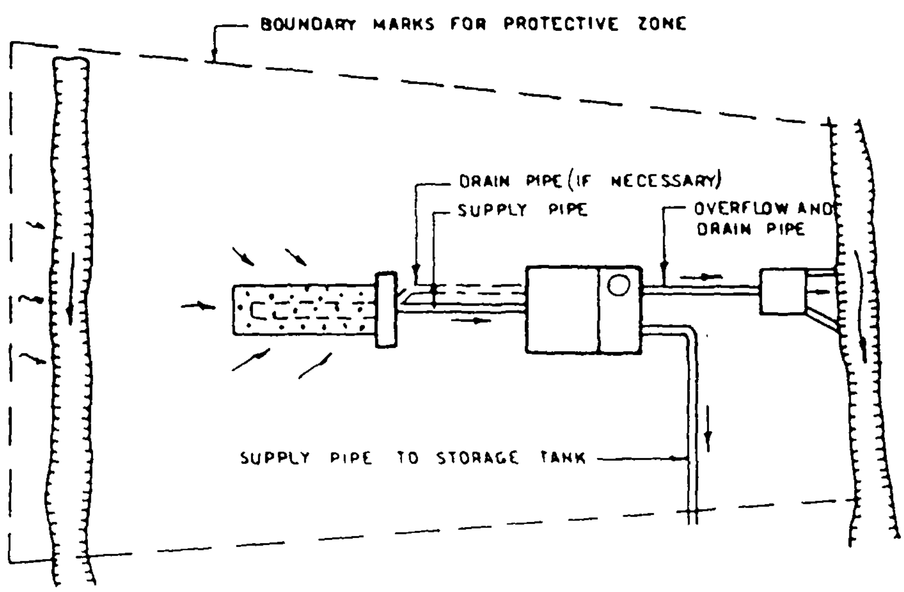
(5) Rainwater: collected from a metal roof may be considered for the supply of drinking in case of a dispersed settlement and source situated only far away.

8. Design and Construction Criterias

8.1. Spring Catchment (comp. Ref [1] page 65-78)

Spring catchment - Lay-out



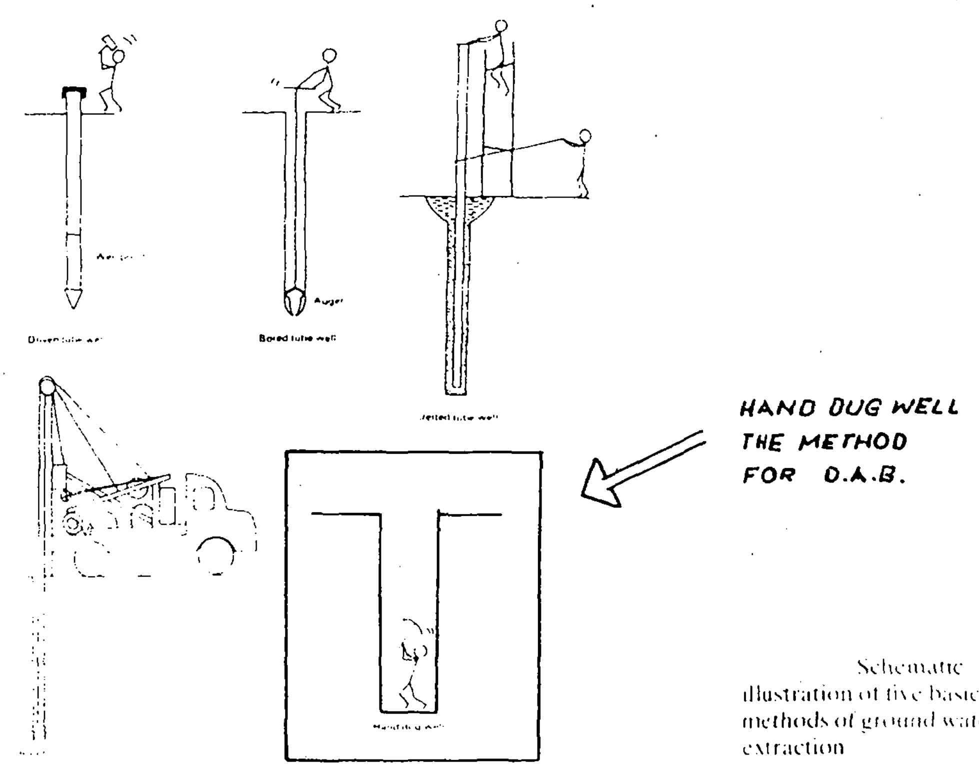


Points for attention:

- legal rights for tapping water
- protection zone: depending on covering stratum radius of protection ca. 100 meters, no farming, afforestion
- underground-catchment: safe covering layer, surface-water drainage
- provision of overflow: no waterpressure behind catchment-construction
- catchment-chamber: avoid entrance over water, provide oferflow, strainer, ventilation.

8.2. Wells (comp. Ref. [1], page 55-64, Ref. [2] and [9] + [10]

Wells can be sunk in a wide variety of ways. The basic methods are illustrated below.



Schematic illustration of five basic methods of ground water extraction

The HAND-DUG WELL is recommended for the Alto Beni Area. The necessary skills are available locally. They don't require special equipment and can be constructed with village participation and with local materials. Moreover the hand-dug well has the very important advantage that water can be drawn from it by bucket and rope if a pump cannot be afforded, or if the pump breaks down.

The present way of construction of wells in Alto Beni is to be improved. Ref. [9] and [10] provide usefuls informations, an example of a designe is shown in Annex II.

The standard of completion is to be decided locally. Annex III shows various standards and discusses their advantages and disadvantages. The following minimum standards are recommended:

for single houses	standard 1
for public wells	standard 2.

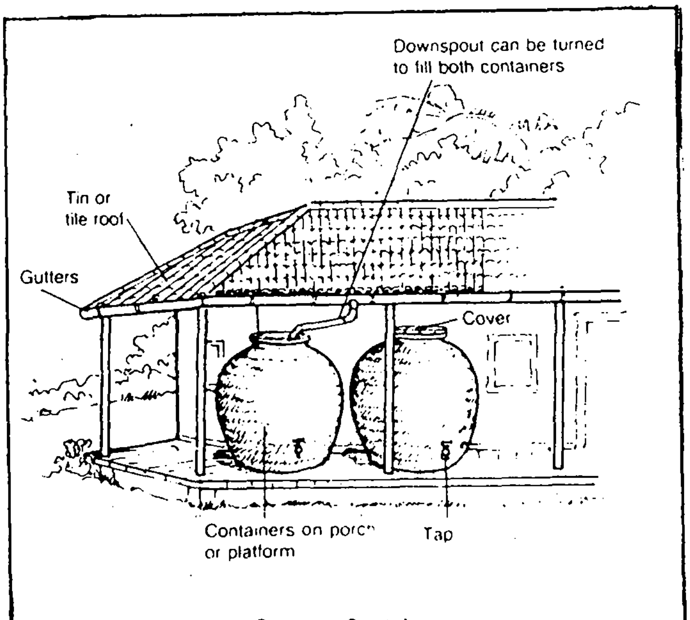
8.3. Stream intakes

Intakes only from small streams are considered. According to the situation of the Alto Beni area. Ref. [1] gives some useful informations at pages 80 to 83. Additional information can be got from Ref. [11].

Points for attention

- choice of location: outside of a bend, firm and solid foundation ground,
- introduction of protection zone above intake
- provision for free flow in case of flood.
- dam to be placed rectangular to flow of stream.
- intake to be situated such that least inflow of sediments are caused (provision of strainer, spilway etc.)
- stilling pool to be placed downstream to avoid corrosion at the foundation of the dam in case no bedrock is available.
- protection of embankments.

8.4. Roof-Catchments (comp. Annex V and Ref. 18)



Large Water Storage Containers

IRC Photo

- Designing Roof Catchments

Roof catchments collect rainfall from a roof and channel it through a gutter into storage for use by individual housholds. The amount of water available for use depends on three factors:

. the amount and distribution of annual rainfall
. the size of the catchment area
. the capacity of the storage-tank (cistern)

For a roof measuring 5m x 8m (in plan), and assuming an average annual rainfall of 750 mm, the amount of rainwater which can be collected in a year may be estimated as:

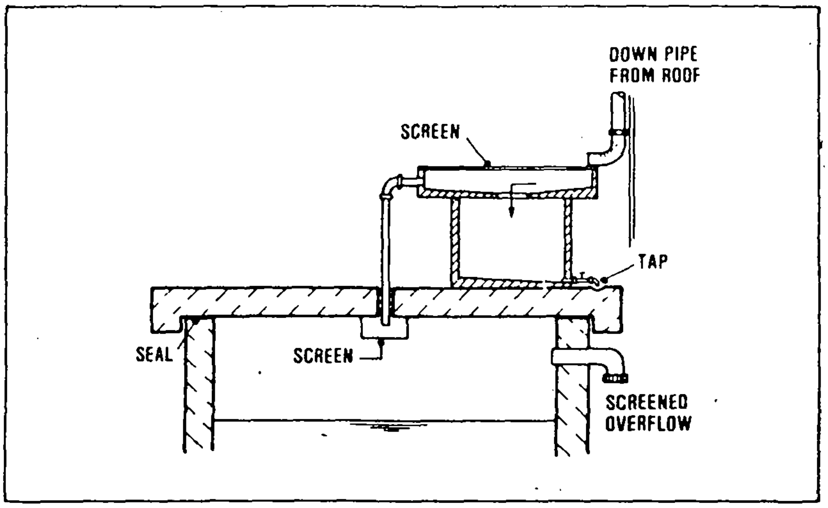
$$5 \times 8 \times 750 \times 0.8^{*} = 24{,}000 \text{ litres/year}$$

$$\text{or: } \frac{24{,}000}{365} = 66 \text{ litres/day on average.}$$

* = factor to consider evapuration etc.

The basic drinking and domestic requirement of a family of 6 persons are 40 litres/day. Assuming an average dry season of 3 months the storage volume required would be: 3 x 30 x 40 = 3600 litres. To allow for longer periods without rainfall in extremely dry years, a 50 %. surplus should be provided and the storage volume would thus have to be 5400 litres.

Dust, dead leaves and bird droppings will accumulate on the roof during dry periodes. These will be washed off by the first new rains. That's provision has to be made to diverte the first showers (the "foul flush") from the cistern and allow it to run to waste. An arrangement for diverting the first rainwater running from the roof is shown below.



Arrangement for diverting the 'first foul flush'

- Constructing Roof Catchments

  - The catchment area is the roof. Roofs can be made of tiles, slates, (corrugated) galvanised iron, aluminium or fibre-concrete sheeting. Thached or lead roofs are not suitable because of health hazards.

  - The roof guttering should slope evenly towards the downpipe, because if it sags, pools will form that can provide breeding places for mosquitoes. Gutters are preferably made of galvanized iron or plastic. Wood or bamboo gutters can be probably made locally but they are often not durable.

  - The downpipe has to direct the water in a collecting box for foul flush. Diverting facilities to waste have to be provided as discussed above.

- Constructing Cisterns (comp. Ref.19)

  There are various methods to constructe household cisterns. They may be done in a classical method like concrete or masonry. But it is essential to look for less costly methods, ferro- or bamboo-cement construction have been applied successfully all over. Though ferro-cement construction is quite simple when the method is understood, it adviseable to collect the practical know-how from an experienced expert.

- Treatment

  A sort of treatment of the rainwater collected from the roofs is recommended.

  . A filter system at the entrance of the cistern is shown at Annex VI. This system will work effectively if frequent maintenance is provided.

  . Various methods of treatment at the households are described in chapter 8.8.2. In this way the water is treated immediatly before consumption which means any pollution of the cistern is elliminated as well. Which may be an advantage to a filtersystem above the cistern.

- Operation and maintenance

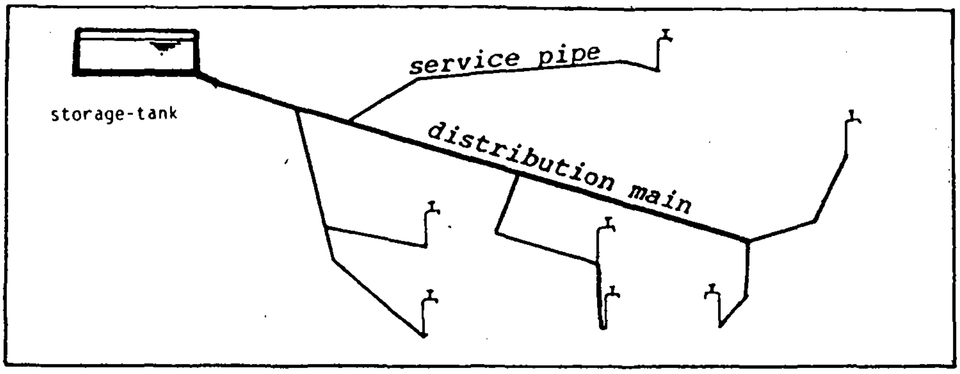
  To safeguard the quality of the collected rainwater, the roof an guttering should be cleaned regularly*. Diverting of the first rains after dry periods is an absolut must. The collecting box for foul flush requires frequent cleaning and drainage. At the beginning of rainfall-periods the cistern should be cleaned thouroghly.

  Since above system is foreseen for individual use, maintenance and operation should not cause any problem in particular so when villagers are proberly instructed.

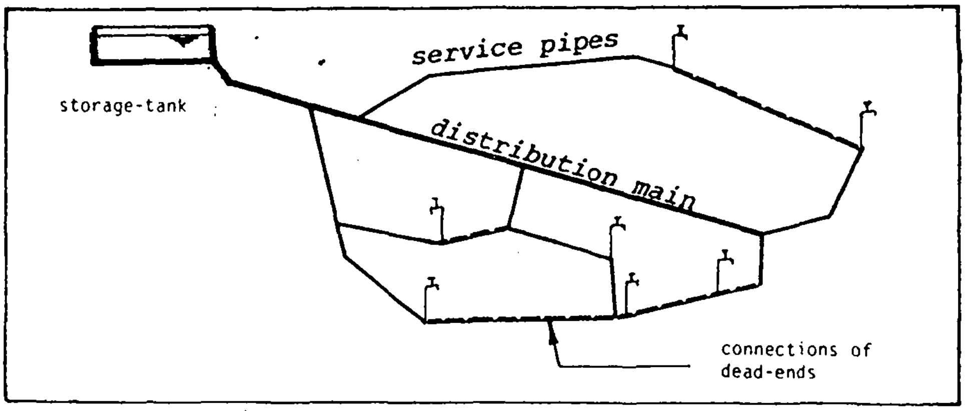
8.5. Supply main

A careful survey of the area has to be conducted to find out the most suitable trace for the pipeline. A layout of the supply and distribution system need to be done including the longitudinal section with hights and slopes. Ref. [1] provides the necessary tables and formulas to calculate the required diametres of pipes (page 110 ff).

Alternative village water supply distribution systems:



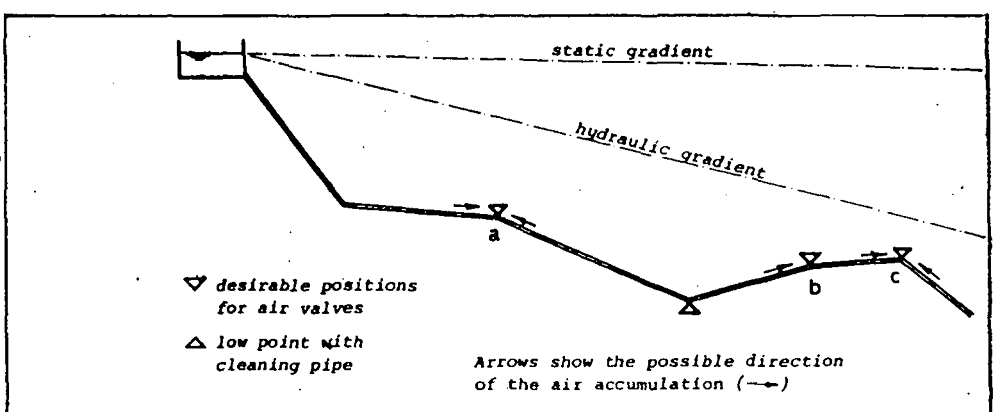
a) Dedritic system



b) Ring main

Points for attention:

- avoid unnecessary high- and low-points, put special attention when laying the pipes.
- provide aeration (airvalves or standpipes) at any high point and drainage facilities at the low points
- prevent vacum after any valves to be closed by providing aeration facilities
- a ring main is preferable to a "dendtritic" distribution so that if a pipe is broken the whole community is not necessarily deprived of water.

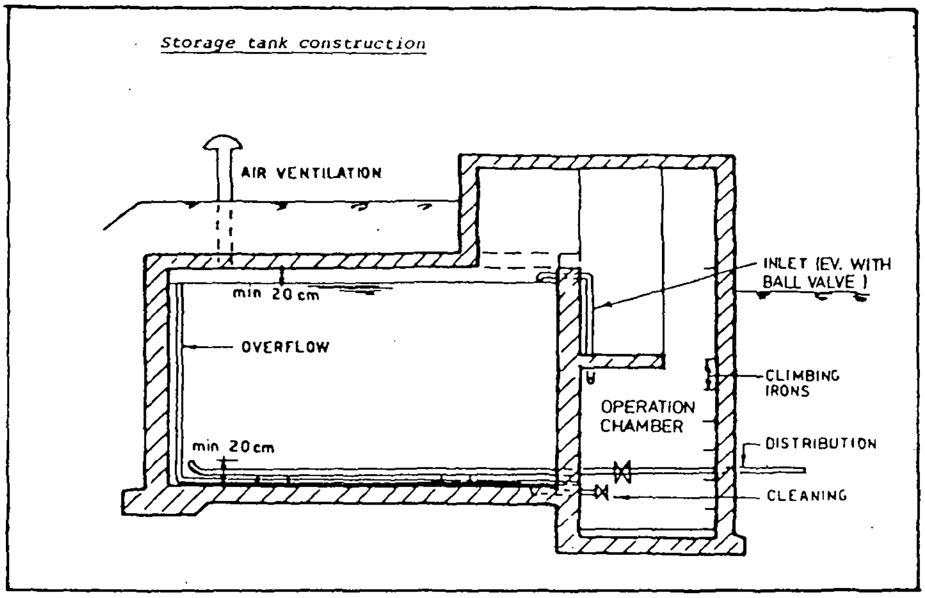


Point a: Air likely to accumulate because of lessening of hydraulic gradient and steeper downgrade in direction of flow
Point b: Lessening of upgrade in direction of flow will cause accumulation of air
Point c: Summit; large air valve for filling purposes will be required

Longitudinal section showing required position for air-valves along a pipeline

8.6. Storage tank (comp. Ref. [1] page 99-102)

Storage tanks are provided wherever the peak demand of the village is higher then the flow from source. In this case the storage tank has to store the water during times of low or no consumption to make it available during peak hours. The storage volume depends on the characteristic of the daily waterdrawings. In rural areas like Alto Beni it should be between 30 % to 40 % of the daily demand.



Points for attention:

- storage tanks should be placed well above the village so that the highest tap still remains with sufficient pressure (5 metres) during peak hours.
- storage tanks should be placed as close as possible to the village so that the distribution main can be shortened (less pressure loss, less cost)
- cover of tank to avoid pollution and breeding of mosquitoes or grow of algas
- provision for ventilation, overflow etc.

8.7. Distribution System (comp. Ref. [1] Ref. [2])

Some aspects of pipeline designe have already been discussed in chapter 7.2.4.

a) Individual connections:

It is desirable to have a supply near each house as already discussed in chapter 7.1.2. for the increase of use of water and the hygiene improvement. In this case it has to be considered that sufficient water is available (ca. 50 liters per head and day). Cost will increase since beside additional tap points larger sizes of supply pipes will be required. But maintenance cost may be lower since villagers care better for their individual taps especially so when an efficient water saving control is introduced incl. disconnections in case of continuous misuse.

b) Public water points

When individual connections cannot be afforded, the alternative is to provide public standpipes and eventually public washplaces for clothes and shower houses if sufficient water is available and no natural bathing facilities are at hand. (The social impact of commen natural bathing places may also be considered). The tap points should be sited in such a way that no one should have to carry water for more then 100 to 150 metres. Public places are naturally more exposed to careless handeling that's why arrangements should be made to give responsibility for each tap point to respected villagers. In addition a caretaker for the entire scheme needs to be made in charge and regular inspection has to be followed.

Points for attention:

- Individual connections should automatically cause a heavier contribution by the individuals towards the construction of the tap points.
- Though individual designes may accepted but they should be of solid construction.

- Areas on which water will be spilt should be paved with concrete and sloped towards the drainage. A hardcore may be placed even outside this concrete to avoid muddy places.
- Special attention should be paied to adequate drainage (soak away pits have to be introduced especially so in case of waterlocked areas (comp. Ref. [1] p. 135)
- Only heavy, durable taps should be installed since a leaking tap makes a heavy loss during 24 hours!
- Special valves should be installed to each connection to make disconnection simple in case of breakdown etc.

8.8. Treatment

Unfortunately, there is no such thing as simple and reliable water treatment process suitable for small community water supplies. Therefore it is preferable to choose a source of naturally pure water, and then to collect that water and protect it from pollution so that treatment is unneccessary.

- Treatment of water at a central station within a village water supply should only be considered if it can be afforded and reliably operated in the future.
- Treatment of water in households may be recommended if an appropriate method is accepted and can be afforded by individuals.

8.8.1. Treatment at a central station

Sedimentation

This may be required in any case if water needs to be drawn from a stream. Especially during the rainy season suspended matters may be washed through the intake into the system. The calculation and designe of sedimentation tanks is discussed in Ref. [1] page 84-89.

Slow Sand Filters (comp. Ref. [1] p. 90-98

If filtration is unavoidable, it should be by slow sand filters. SSF improve the micro-biological quality of water considerably and their mode of action is quite simple. Water passes by gravity downwards through a sand bed about 0.45 to 1,0 m thick, at a rate of less then 0,3 m/hr. At the top of the filter bed a layer called "Schmutzdecke" develops which contains the quality of bacteriological treatment. The bed requires cleaning at frequent intervals. This interrups the bacteriological efficiency. To lengthen the intervals for cleaning especially during the rainy season pretreatment with horizontal-flow Roughing Filtration is recommend (comp. Ref. [12]).

Operation and maintenance require skilled personnel and cause additional cost (ca. 5 man days/a month for a village of about 4000 people).

SSF are not recommended for D.A.B. at this stage. But in case of stream intakes provision should be foreseen for futur installation. Villagers need to be advised to apply individual treatment methods described below.

Chlorination

If water needs to be completely free of pathogens, it is necessary to apply a chemical disinfectant. Chlorine is the disinfectant mostly used all over. The correct dosage of chlorine requires some skill and a special apparatus for continuous adequate dosage. Since this preconditions are difficult to guarantee in rural areas all year round, this method is normally not to be recommended.

Storage

According to Ref. [2] the simplest method of treating water is to store it in a covered tank. Some treatment may be obtained by careful design of storage tanks to ensure a slow and even movement of water from the inlet to the outlet, as in a sedimentation tank. This will permit some silt to settle out, and allow time for some pathogens to die off. If water is stored for at least forty-eight hours, for instance, any schistosome cercariae in it will become non-infective before they leave the tank.

Wether this method is appropriate in certain cases of D.A.B. depends on the type of pathogens which have to be expected as potential health hazards.

Removal of minerals

Heavy concentrations of dissolved iron and manganese in the ground water can give it an unpleasant taste, and give a brownish colour to food and clothes. They can be removed by aeration. A possibility for aeration is provided by Ref. [2].

According to the preliminary site investigations in the Alto Beni area, no such treatment is expected to become necessary for D.A.B.

8.8.2. Treatment at the households

The methods for treatment described below are recommended especially for households of dispersed settlements, which have no closely access to a safe source of drinking water. But also individuals of village settlements may apply this methods, if they are aware about the importance of waterquality and are disatisfied with the quality of water supplied at the tap point (e.g. in case of stream intakes etc.).

- Boiling of water

  Boiling of water is probably the most known way of treating water. Unfortunately this method has some points of disadvantage as follows:

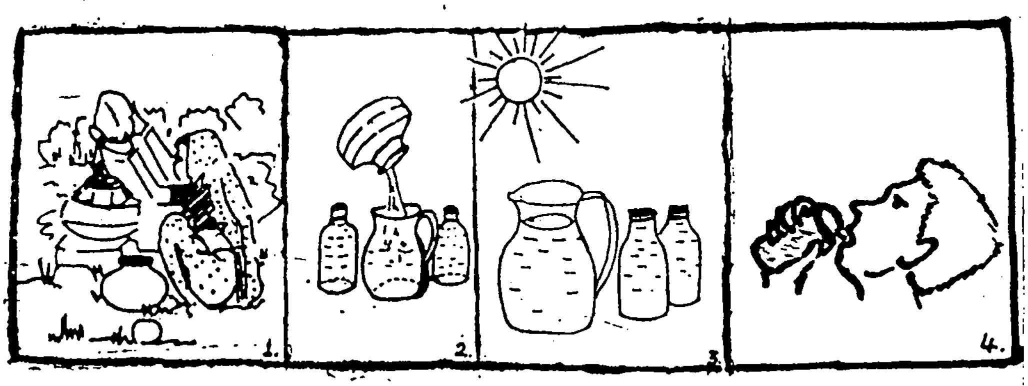
  . Water has to be kept at the boiling point for at least 15 minutes before all pathogens are killed

  . Firewood is often scarce or at least its collection a burden, so that even if water is boiled before drinking it will be done only insufficiently.

  That's why this method is only partly recommended for D.A.B. even firewood may be available in plenty.

- Solar disinfection

It seems that solar disinfection of water has been known in some culturs since history. A systematic research has been done on this method since 1979 at the American University of Beirut. They have come up with surprisingly results which confirm the fact that the bacteria contaminating water from faecal sources are, as a general rule, susceptible to destruction upon exposure to sunlight for an adequate periode of time. Guidelines for household application have been published recently by UNICEF [Ref. 13]. This guidelines are recommended also for its instruction on the preparation of oral rehydration solutions. Though the method has not yet been tested in the field in a broader scale it should be considered as a cheap, simple and appropriate method for D.A.B.



Destructive effect of sunlight on bacteria in oral rehydration solutions contaminated with sewage

- Traditional Water Purification

The conditions in the tropics with abundant growth of microbes and the occasional need to survive on any foul water available, may have provided the stimulus for the discovery of methods of purification and for their recommendation in socio-cultural legislation even before the lawn of history. Most religious require pure water for worship and ablutions and certain "sacred plants" encountered in rites can be called "purifiers" in the light of modern scientific understanding.

Many of these methods are still hidden and need to be rediscovered. S.A.A. Zahn has written a very interesting book on this subject [Ref. 14]. He states that in South America records of traditional watertreatment with natural coagulants have been available for several centuries. In Peru, Kirchmer has done some research in the efficiency of the traditional method of using Opuntia ficus indica and related species as a flocculant [Ref. 15].

Even during my short stay in Alto Beni Area I experienced personal the existence of traditional knowledge on this aspect. A farmer, who had provided me drinking water, informed me to my fright that I had just drunk water which had been drawn from the heavy polluted Beni river, but he would have treated it with lemon juice. Do my surprise my otherwise sensitive indestines did not show any reaction of infection. But I came recently accross an article which confirms that the addition of cordials to water kills pathogens.

Traditional water purification should be considered as a useful alternative for D.A.B. But the existing traditional methods should be carefully observed and evaluated in considering as well the scientific principles. E.g. pollution today may be more serious then in the past and traditional methods may not be efficient enough.

- Household Filters

There are many types and models of filters which may be applied at the level of households. A study has been undertaken by the Central American Research Institute for Industry in Guatemala (Ref. [16]).

This method is only recommended for D.A.B., if some people private or officials are interested to investe time and effort to adapt it to the local context (selection of most appropriate model, local manufacturing, maintenance etc.).

8.9. Raising of Water

Methods of lifting water are numerous and varied. The two main criterias which should be fulfilled by any device to raise drinking water are the following:

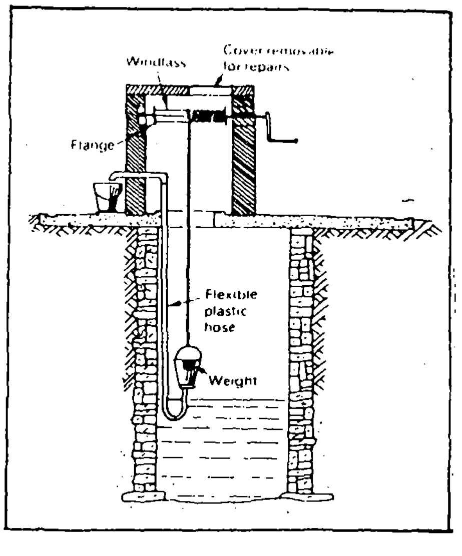
1) The device should do its "job" with the least maintenance and be the means to raise the water under the local circumstances.
2) The device should be designed in such a way that by its usage the good quality of the groundwater remains sufficiently protected.

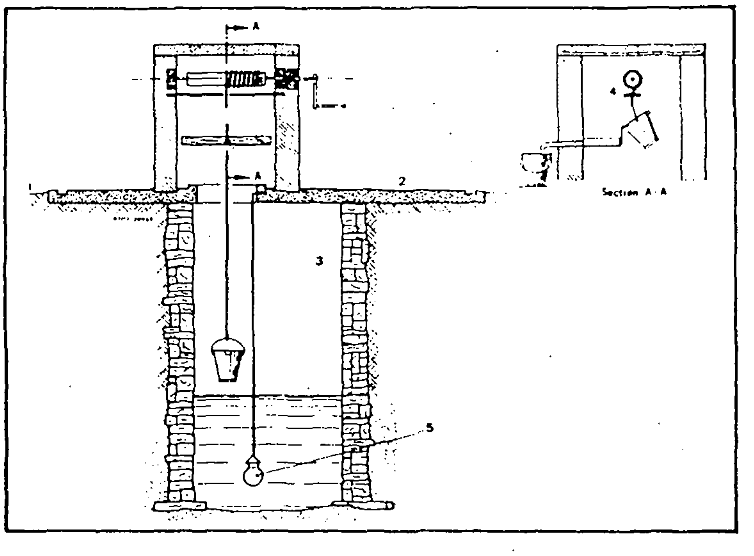
The recommendations given below consider as much as possible these two criterias, but local adaption to the context of D.A.B. may be still required.

8.9.1. Improved bucked systems (comp. Annex III Type 2)

These systems are recommended for individual wells in dispersed settlements. They may also be used at public wells, when villagers are not ready to accept the advantage of handpumps and/or their maintenance cannot be guaranteed.

The three types shown below should be taken as an idea, they need to be adapted to the local conditions and acceptance. It should be considered that in any of the systems the bucket and rope remain permanently at the well site and are therefore less exposed to contamination.





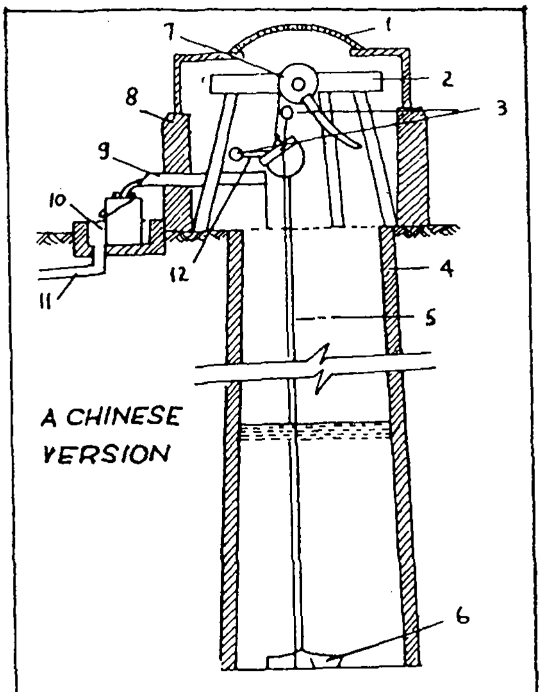


Fig. 16. Draw well with windlass (1, entrance; 2, frame; 3, fixed shaft; 4, seal; 5, track; 6, fixed stand; 7, windlass; 8, tight seal; 9, trough; 10, position for bucket; 11, ditch; and 12, stop hook).

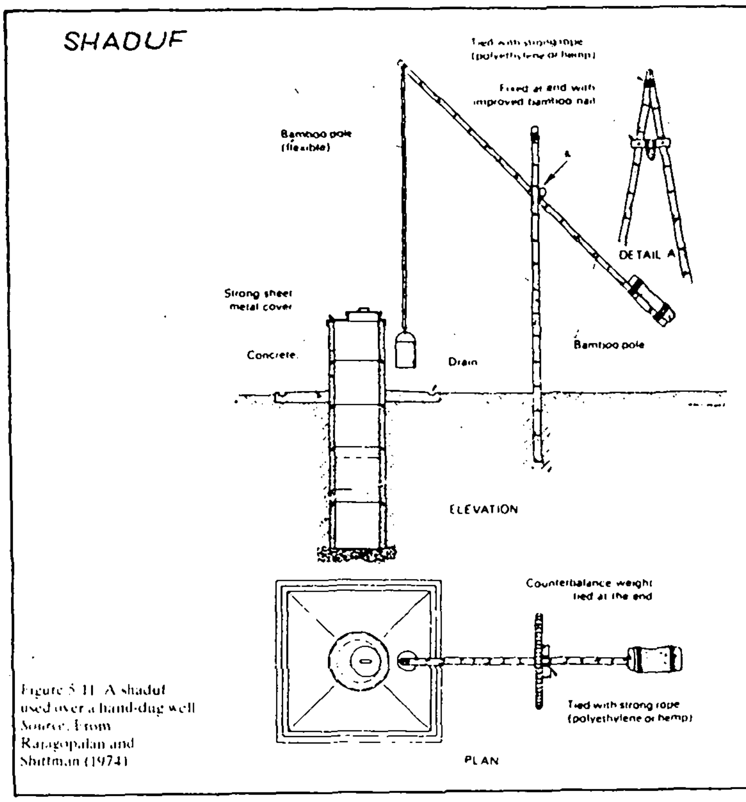
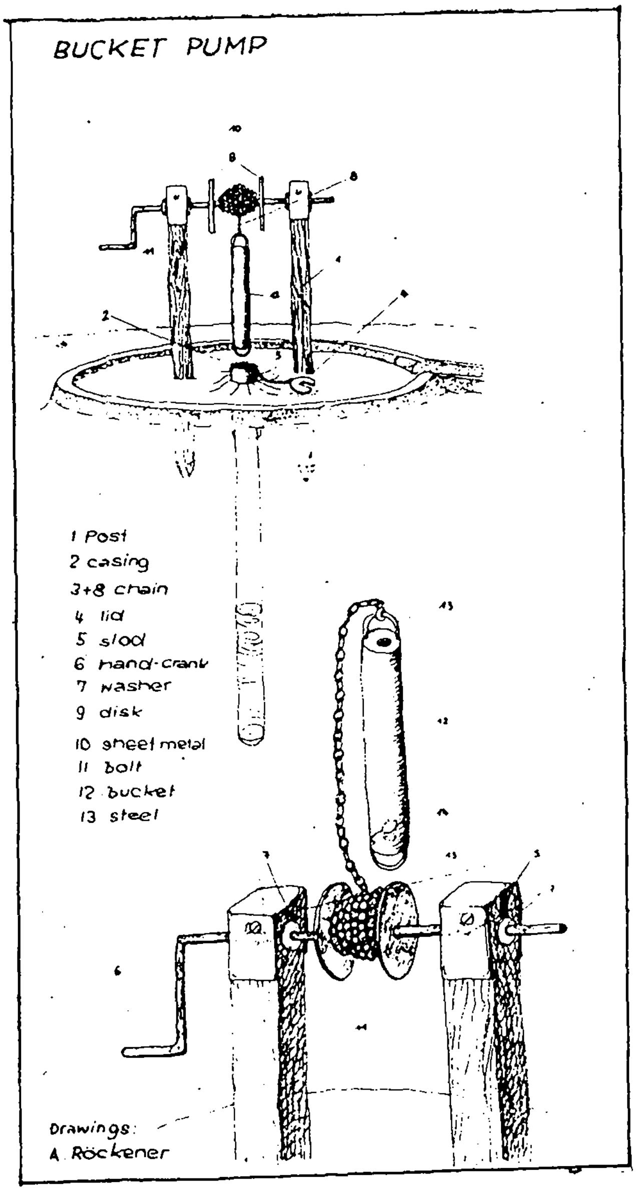
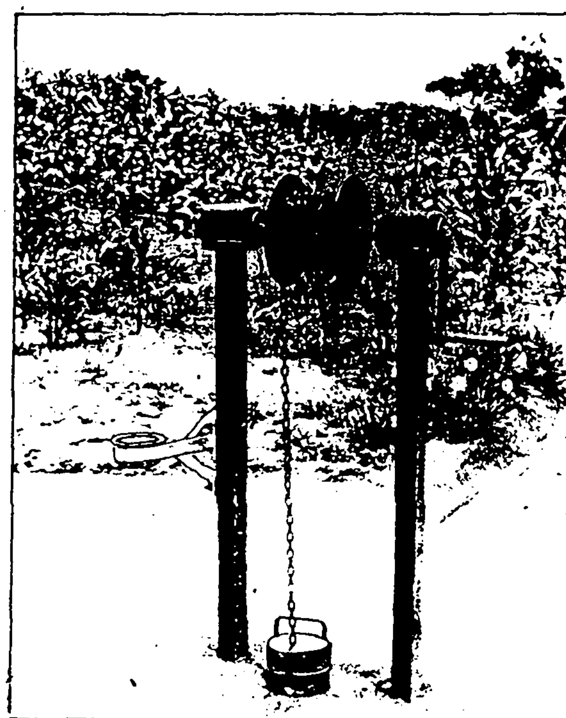


Figure 5.11 A shaduf used over a hand-dug well
Source: From Rajagopalan and Shiffman (1974)





The Bucket Pump is designed to be used in wells drilled by the Blair's rig. The aim is to reduce contamination by ensuring that people's hands do not need to touch the 'bucket'. The steel bucket has a simple steel poppet valve in its base, so fills automatically when it reaches the water table. It is drawn up by a chain and windlass and placed in a special holder on the framework which releases the valve, discharging the water directly into the user's bucket. The whole assembly is made of steel, except for hardwood bearings. Supplied with 15m of pvc well casing, the Bucket Pump costs $(Zimbabwe)250

8.9.2. Hand pump

Ref. [2] p. 70-73 provides a quick view over the issue of handpumps.

A hand pump provides entire protection of the groundwater from pollution until it enters the user's bucket (comp. Annex III 3a and 3b). It cannot be produced at village level. Recent studies and test on various type of pumps put more light on the complexity which are involved in hand-pump development, production and social acceptance. Most important - hand pumps require frequent maintenance wich asks for adequate organisation, skilled personnel and required financial.

In the long run handpumps will be certainly the appropriate devices to draw water from drinking water wells in D.A.B. But it is not recommended that D.A.B. should go for its own handpump or even start to select the most appropriate pump from among those one which could be imported. Since UNDP/Worldbank is undertaking competent field tests in Bolivia, D.A.B. is advised to waite for the results of this investigation. SKAT is assisting similar testing programmes of UNDP in Africa, contacts with SEMAT for investigations on local production are on the way. At the time more informations and facts are available SKAT is prepared to give further advise.

8.9.3. Windmill

Though this system is running on wind, a natural source of power without cost, this system is not recommended for D.A.B. The disadvantages of the system are its relatively high cost but also its dependence on continuous blow of wind.

8.9.4. Solar pump

Solar pumps have been installed in arid areas. Not only their cost is high but they involve sophisticated technology. That's why they are not recommended for D.A.B.

8.9.5 Hydraulic Ram (Ref. [1] p. 148 + 149, Ref. [17])

A hydraulic ram uses the energy of flow of a large volume of water, to pump a small portion of that volume to a higher altitude.

The preconditions for the application of a hydraulic ram are the following:

- Excess flow of spring
- sufficient drop after the spring

(e.g. When the lift of water from the spring to the storage tank is 25 meters and the drop after the spring is 5 meters about 1/8 to 1/7 of the flow can be raised.)

If the site circumstances permit the installation of a hydraulic ram, this is an excellent solution which requires only very little maintenance.

8.9.6. Water turbine

Like the hydraulic ram a water turbine uses energy of the flow of water either from the spring or an additional source e.g. stream to pump the water to a higher station. Though this system is very appropriate whenever the site circumstances permit its installation, it is not recommended for D.A.B. because of the relatively small amounts of water to be raisen and the complexity of installtation and operation.

8.9.7. Engine Pump

Though engine pumps may be available, they are not recommended for D.A.B. because of its high running cost, continuous maintenance - and replacement - requirements.

9. Construction-material and -method for Water Supplies

The criterias which determine the appropriateness of construction-material and -method have been listed in chapter 4.2. Considering these aspects the following recommendations for D.A.B. are given for the various elements of a water supply scheme.

9.1. Chambers and Storage-tank

Standard designes should be designed for different sizes of chambers and storage-tanks (e.g. 5 m3, 10 m3, 15 m3 etc. storage tanks). This standardization should include careful calculation of required reinforcement, list of material as well as man days required. In this way faults can be minimized and the organization of work is simplified. (The standard designes may be checked by an experienced consultant e.g. SKAT.)

9.1.1. Foundation and floors

Since the tanks would be normally beared into the ground (to keep the water cool), the bearing capacity of the soil should be such that no special measurments for the foundation should be required. - A lightly reinforced slab of 15 cm thickness and a concrete of the quality of PC 300 (comp. tabel) should be sufficient. Vibration of the concrete, which is to be placed on a layer of 5 cm thick lean concrete, is highly recommended.

9.1.2. Walls

According to the local skill of building contractors the walls may be casted in reinforced concrete. Vibration of the concrete PC 300 is highly recommended to get at the highest possible tightness of concrete, in particular in the few of the aggressivity of spring-water which must be expected. For the same reason the cover of reinforement should be at least 2,5 cm.

At those sites where reasonable stones (min. diametre 15 cm) are available a stone-masonry wall may be considered. The qualitiy of any masonry work has to be at a very high level. All stones should be bound entirely in mortar but joints should have a thickness of 1 to 2,5 cm. Stonefaces should be planely shaped. Binding stones should cross the walls to 2/3 at intervals of ca. 1 metre. If the qualified skill for such stone masonry is not available, this method can only be recommended when adequate training is provided.

9.1.3. Cover Slab

Reinforced concrete (PC 300) is the most appropriate method for this element. The waterproof slab should slope away from the entrance and it has to be covered with soil to keep the water cool.

9.1.4. Plastering / Protection Coat

Special attention has to be paied to the plastering, since it determines the water-proofness of the tank and its life time to a great deal. A waterproof plastering should include the following layers:

1. Spatterdash:	thickness of 3 - 5 mm twice (lap 6 hours)	
	mixture:	1 : 1 and 1 : 1,5 (flowing)
	sand:	0 - 2 mm
2. Floating coat:	thickness of 10 - 20 mm	
(rendering coat) (lap 1 day)	mixture:	1 : 2 till 1 : 4 normaly 1 : 3
	sand:	0 - 5 mm
3. Setting coat:	thickness of 2 mm	
(lap 1 day)	mixture:	1 : 2 to 1 : 3
	sand:	0 - 2 mm
4. Cement paste:	thickness of 1 - 2 mm	
(lap 1 day)	mixture:	pure cement with water or mixed with 1 mm sand not less then 1 : 1

All corners should be rounded e.g. with a bottle to make cleaning of the tanks easy.

A protection coat against the aggressivity of spring-water has to be applied wherever the pH is below 7,0. The available products for protection have to be carefully evaluated. They should be of accepted standard to be applied in drinking water supplies.

9.1.5. Points for attention in selecting the building material

- Cement has to be of a quality according to international regulations
- Cement should not be hardened and rebroken, (store it only at dry places, in a distance from floors and walls)
- Gravel and sand should be of clean quality: no organic material, no clay or silt (apply bottle test e.g. put a sample of sand into a clean glas-bottle and shake it thouroughly, then alow the material to settle, if clay, silt or organic materials are present, they can be easely traced.) If washing of the sand is required, it has to be done carefully so that the finer aggregates of the sand are not washed away together with the silt. River sand when properly selected is normally of reasonable quality.
- The timber to be used for the shuttering of the concrete work should be well seasoned and planed. Even if the initial cost for these timber may be higher it will be cheaper in the long run because it can be reused. But more important is the fact that a high quality of concrete can only be got with a solid shuttering

All concrete-works including plastering have to be well cured which means protected from exposure to sunlight but continuousely kept wet by watering for at least 2 weeks after casting!

9.1.6. Some designe criterias

- The entrance should never be directly over the watersurface for hygienical reasons. Preferably provision for the entrance should be made from the operation room
- Standardized tight entrance doors may be designed and constructed (prevent corrosion)
- Ventilation of chambers and tanks is essential but they need to be covered with mosquito mesh.
- The drainage arrangement should be such that no small animals can enter the tank (comp. Ref. [1] p. 76)

9.1.7. Alternative Methods (Comp. Annex VII)

Circular ferrocement tanks are replacing "classical" storage-tank construction in many places. This method is making use of the performance of reinforcement-iron and concrete in a most economical way. The required reinforcement is provided with horizontal rings. Wiremesh which is fixed to it gives hold for the plastering. The plastering which is applied in various layers from in and outside covers and protects the reinforcement as well as provides a waterproof coat.

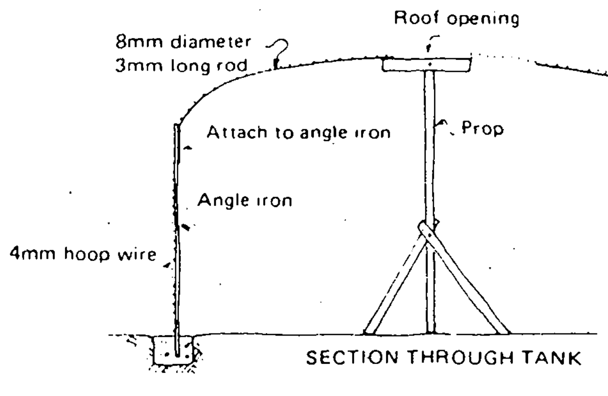
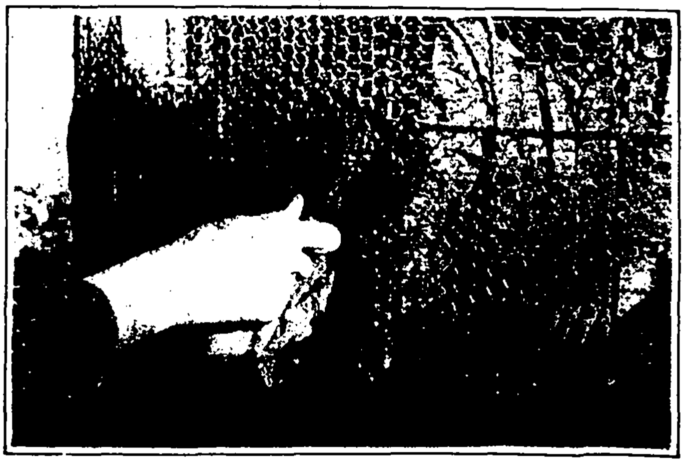


Fig.38 Building the roof



Plaster on core wall

Since the method is not difficult to learn and it is very economical at the same time, it is recommended, that either a skilled mason (foreman) of D.A.B. undertakes special training or an experienced expert is invited to introduce the method to D.A.B. on one of the pilot projects. Ref. [20] and Ref (21] give practical informations and instruction about the construction of storage tanks in ferrocement.

9.2. Distribution Buildings

Standpipes and washplaces etc. should be of robust and solid quality. Concrete work is to be prefered. Basins may require plastering but pillars etc. should be vibrated in such a way that the concrete surface is even and compact so that no plastering is required. Only well seasoned and planed formwork should be used.

Special attention should be paied to the surrounding work including drainage, fencing and providing of a hardcore at the entrance.

Experiences all over have proven that clean and attractively prepared buildings etc. are taken care for in a personal way even if they are meant for public use.

9.3. Piping

In accordance to the aggressivity of spring- and ground-water in Alto Beni area plastic pipes of polyvinylchlorid (PVC) or polyethylene (PE) are recommended. Their quality has to follow international standards for drinking water pressure pipes. It is recommended to apply the heavy type (for high pressure: nominal pressure 12 atm.) because of exposure to rough handeling in transporting etc.

Since plastic pipes are probably still a relatively new product and its proper handeling is not entirely known, some additional hints are given below for handeling and application.

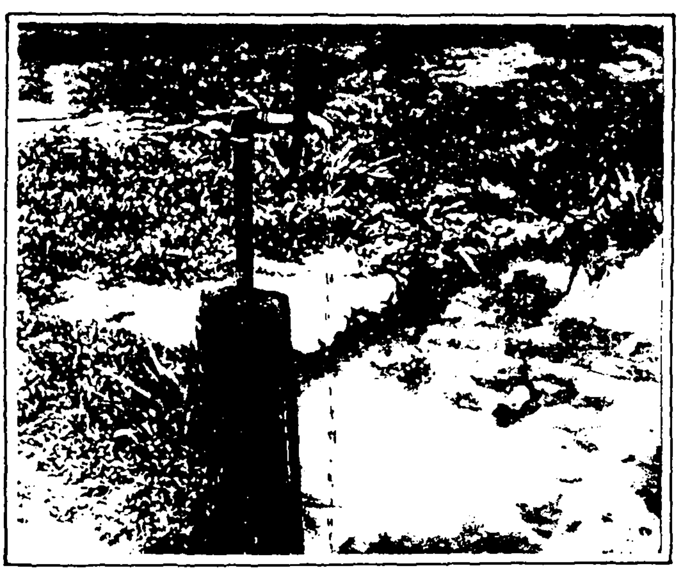
- When transporting plastic pipes, it is essential that the bottom row of pipes is supported along the entire lenght of the truck.
- Pipes can be stored outside for an unlimited time but it is adviseable to protect them from direct exposure to sunlight. Pipes must be stacked on an even surface. Wooden batons may be placed at the base and in-between each layer in a distance of about 2 metres. Supports from the side should support the pipes evenly and be placed in intervals of less then 2 metres.
- The laying of pipes should be done adequately as instructed in Ref. [1] p. 105-134. Unnecessary high- and low-points have to be avoided that's why it is essential to check the gradient of each pipe with a spirit level. Since plastic pipes have only limited resistance towards pointed pressure, they need to be prevented from direct contact with stones and rocks.
- The cover of plastic pipes in the trenches should be about 90 cm. This cover is most essential since it protects the pipes sufficiently and guarantees a long service life. Exposure of plastic pipes to sunlight has to be avoided since plastic tends to detorate under the influence of UV-rays and becomes brittle. This means that wherever plastic pipes can not be sufficiently covered they need to be protected e.g. by inserting them into steel-pipes, concrete channels or by building dry walls around them.
- The joints of PVC-pipes may be glued together. In addition to the instructions by the manufacturers the following precautions should be taken:
  . Since different makes of PVC-pipes apply different glues, make sure of the correct make of glue
  . Joints need to be thouroughly cleaned. Special cleaner solution is recommend to remove any grease
  . Before the glue is applied additional cleaning with sandpaper is recommended
  . Apply glue and joint pipes according to the instructions by manufacturers.

(In case PVC-pipes with sockets and rubber sealing rings are available, they may be prefered to the glued type.)

- PE-pipes may be used if they are available together with the required equipment for welding etc. Ref. [22] provides instructions about the application of PE-pipes.
- Galvanized iron pipes (G.I. pipes) have to be carefully checked for its quality. Even if they are of good quality they are likely to corrode in case of pH below 7 or excessive carbon dioxide and low hardness (comp. Ref. [1] page 22-28). That's why the application of G.I. pipes should be limited as much as possible.

9.4. Taps and Valves

Taps and valves should be of robust and heavy quality. In particular taps are exposed to rough and unadequate handeling. It should be noted that the loss of valuable water from a leaking taps can be very significant and cause shortage. That's why the available make of taps need to be carefully evaluated. In case no adequate local product is available it may be adviseable to import a fieldprooven make from abroad. Selfclosing taps are essential if they are not too hard to operate but can also not be blocked with local measures. They have to be as durable as possible, springs for instance tend to break quickly. Spareparts have to be made easely available but costs need to be covered by the consumers (comp. chapt. 10).



LEAKING TAPS:

A commen view at existing water supplies in Alto Beni Area.
Tough locally repaired heavy loss of precious drinking-water and potential for health hazards

10. Operation and Maintenance

10.1. The actual situation World wide

The construction of new or improved water supplies does not necessarily solve the problem, without the capability to operate and maintain the water supplies which have been built. Construction is relatively easy compared to the task of keeping new village water supplies running even if they are small and simply designed. Frequently, not enough money is available to cover operating costs and to carry out running repairs, let alone to carry out necessary preventive maintenance. Operation and maintenance require a long-term commitment of money, men, and institutions. This can be a major drain on the resources of a developing country. Besides it is usually more attractive easier to obtain development finance for the construction of new water-supplies than funding for the recurrent expenditure of a maintenance programme. Even where the money is available, there is frequently a shortage of technicians and a lack of viable institutions able to carry out the job.

In typical developing countries, over a quarter of their rural community water supplies are out of action. Many of those still running provide water of doubtful quality or are exposed to frequent break downs and water shortages. Some countries rely upon community involvement to maintaine supplies, but even this method has often failed. Broken-down supplies represent an enormous wastage of investment all over. More serious may be even the fact that villagers who have invested their own efforts for an expected improvement of their basic need of drinking water get frustrated and feel laied down by false promises.

Much could be said about the problems of operations and maintenance but the following points stated in Ref. [2] may serve to highlight the problem:

(i) most developing countries have large numbers of broken-down of faulty supplies;

(ii) there is no point in building water supplies only to allow them to break down within a few years;

(iii) operation and maintenance is the most deficient area in most water supply programmes;

(iv) operation and maintenance is very difficult and requires more efforts, not less, than construction if success is to be achieved.

10.2. Consequences for D.A.B.

10.2.1. Survey and investigate existing water supplies (comp. checklist page 21)

Learn from the successes and shortages of different operation and maintenance systems in Alto Beni and other areas. Adapt the most appropriate system for the particular context of Alto Beni. Already for this planning stage of the maintenance method the community concerned has to be consulted, involved and asked to participate to find an acceptable solution. This involvement of the villagers has to be combined with adequate education on the need and importance of this issue.

10.2.2. Some hints for maintenance- and operation-organisation (comp. Ref. 24)

- As already discussed in previous chapters the water supply schemes need to be designed and constructed for maintenance and operation. Which means that the local resources, possibilities and capabilities of the villagers and institutions have to be carefully considered. The proposal below tries as far as the local context is known to the author to provide some useful hints.
- Since the settlements in D.A.B. are scattered and many of them are difficult to be approached all year round it is adviseable to introduce a decentralized maintenance system. This means that the task for maintenance has to be as much as possible with the users of the water supply. It is obvious that such a direct maintenance scheme is only possible when the villagers are convinced about the necessity of maintenance. Hence in D.A.B. much emphasis has to be paied to the education and motivation aspect.

- The maintenance organisation for different water supply systems which may be applied in D.A.B. could be arranged as follows:

(1) Gravity watersupply for villages (nucleos): One or two capable and well respected villagers are trained during construction of the water supply on the maintenance work. This on the job training is to be followed up with a two weeks caretaker course, which should provide some more theoretical background both on the technic and on health and hygienical requirements. Villagers are educated and trained during project realization on their responsibility for maintenance.

The organisational set up could be as follows:

. A village water supply committee takes the responsibility for the operation and maintenance of the water supply. They decide upon a request by the caretaker or complaints by a villager about the necessary measures to be taken. E.g. stopping of supply to a badly maintained standpipe, cleaning of storage-tank by a group of villagers, stopping of illegal farming within the intake area etc.

. The care taker is responsible for all technical aspects required for maintenance. He keeps the spare parts and required tools. He operates and maintains the communal parts of the scheme (e.g. intake, catchment storage-tank, pipelines, valve-chambers etc.). He advises and supervises the individual connections like standpipes, washplaces etc. He reports periodicaly to the water supply committee. He receives for his part-time job an adequate allowance.

. The villagers are responsible to maintain the distribution buildings, standpipes, washplaces etc. as well as to participate in commen maintenance work like cleaning of storage tank etc.

. It is essential to have a supervisory body who checks periodically the work of the caretaker from the technical point of view. Just so the quality of the water may be examined at the same time. It is obvious that this job has to be done by an official authority.

. The financing of the maintenance work, required spare-parts and building material is probably the key question which needs to be carefully solved and clearly defined in considering the capability of the community concerned realistically as well as of the official institutions who could be involved.

(2) Water Supply from dug wells: As already discussed in chapter 8.2. and 8.9. the standard of a well construction respectively of the device to raise the water depends much on the capability for maintenance.

As simple the recommended system (type 2 of Annex III) is it still requires frequent maintenance.

The organisational set up for maintenance may be somewhat similar as proposed for gravity water supplies.

The responsible caretaker has to keep in good working condition whatever the commen device to raise the water is. He has to supervise and advise adequate usage, cleaning of surroundings and in particular to guarantee a proper drainage of any wastewater. Spareparts and financials for replacement have to be kept ready.

(3) Supply from a spring below the village

(3a) Waterpoints The organisational set up for maintenance may be similar as suggested for gravity water supplies. Though the maintenance work will be less, the task for maintenance and a clear organisation should not be underestimated.

(3b) Supply from a spring by a hydraulic ram. The system corresponds with a gravity water supply with the addition of the hydraulic ram. Since the hydraulic ram when properly installed won't cause any significant additional maintenance work or cost, maintenance may be similarly organised as suggested for gravity watersupplies.

(4) Supply by gravity from a stream. It has been argued in previous chapters that this system should be only applied if all other possibilities fail. It has been also recommended that for the time being a central treatment station (slow and filters) should not be constructed but space for futur installation has to be foreseen. Nevertheless a sedimentation tank has to be constructed to guarantee continuous supply also in rainy season. Just so individual treatement of drinking water is recommended (comp. chapt. 8.8.).

Though cleaning of intake and sedimentation tank will increase the maintenance work for the caretaker in particular during rainy season the organisational set up will remain like for gravity water supplies.

(5) Roof catchments. Since roof catchments are suggested for individual use, direct maintenance by the users should not cause any problem in particular so when the users are properly instructed. That's why special seminars should be organised where the background informations are explained and the required maintenance work is demonstrated. An illustrated checklist may be of help for the users. Some important points to be taken care for are the following:

- clean roof and guttering regulary from leaves birddroppings etc.
- divert the water of the first rains after dry periods to waste
- clean and drain frequently the collecting box for foul flush
- clean thouroughly the cistern when the rainy season has set in.

10.2.3. Time schedule as when to introduce the maintenance component

Because of the importance of the issue it needs to be underlined ones more that mainteanance work can not be thought about when a watersupply is constructed but needs to be considered in all its consequences in the planning stage!

10.2.4. Point of special attention: "Give more consideration to women"

The importance of this aspect would in fact call for a chapter on its own. - Water collection in D.A.B. area is traditionally women's work, even if they are assisted to a great extend by children. In its consequence it seems to be obvious that women should be considered as the main target group to deal with in the realisation of water-supply projects. Although this fact has been realized in many other areas and a lot has been said about the need for involving women but as yet little has been put into practice. This neglegtance has contributed heavily to the disastrous failure rate for improved water supplies.

Since the particular role and position of the women in D.A.B. area are not known to the author only some ideas and hints on how to deal with this important aspect can be given below.

- Women need already to be included in the planning stage in particular in the view that the projects need to be designed for maintenance. The policy should be to build on existing practices instead of trying to do away with the old order and introduce a completely new pattern of living.
- Naturally the health education programme should be mainly adressed to the women concerned.
- Women should participate in the implementation stage including adequate free labour contribution as well as decision making.
- Women who are responsible for fetching water, washing etc. should also maintain the tap points incl. their surrounding.

The main question after all is: "HOW CAN WOMEN BE EFFECTIVELY INVOLVED?"
Again some hints are given below:

- The starting point must naturally be an understanding of women's present situation incl. the reasons behind the position and status of women in the society.

- It is essential to employ at least one better two female project staff. (Women staff are expected to identify more easely with village women and on the other hand village women will be more open to women staff).
- Women should at least attend in water supply planning meetings, though they may hesitate to speak in such open meetings. In addition they should be allowed to express themselves in all-women meetings. Women should be also represented in any water supply committee.
- Methods of health education etc. should consider the capability of receiving messages by women. E.g. Talents in the field of drama and dance often have no relation to status or educational standard, and are therefore an area where women from all social categories in the village could participate as can children.

More informations about this most important aspect can be got from relevant literature e.g. Ref. [25].

.....Water for domestic use is women's "buisness".....

⇩

....Women have to play an important role in water supply projects....

10.2.5. Some observations at existing water supplies of D.A.B. area

Since villagers may not understand the implications of maintenance work at the beginning stage, project committees may be invited to inspect existing watersupplies which provide with their short comings enough evidence for the necessity of proper planning and implementation of maintenance work. Some examples which were found by the author at few field visits in Alto Beni area are the following:

- leaking taps at the standpipes but no drainage → standing water, swamps → breeding places for mosquitoes, hork worms and other parasites
- unsufficiently covered pipes → frequent breakages, complaints about long periods of no supply, high cost for new pipes
- wrong selection of piping material → corrosion of pipes → rosty water → shortage of water
- stream intakes insufficient foundation → washed away by floods → blockage after each rain
- unprotected intake area → farming activities → pollution of spring water → increase of diarrhoea
- unhygienical distribution buildings - unhealthy villagers in particular children suffering of diarrhoea.

A standpipe of an existing water supply in Alto Beni area:
leaking tap, no hardcare, no drainage
→ standing water, muddy place
→ breeding place for mosquitos, hork worms and other places
→ unhealthy villages in particular children suffering of diarrhoea

⇒ NO EFFECT IN HEALTH IMPROVEMENT BUT INCREASE OF HEALTH HAZARDS!

47 H.H.M. Haldenwanger
Biologische Zerstörung der makromolekularen Werkstoffe, Bd. 15, der Reihe Chemie, Physik und Technologie der Kunststoffe, Ed. K.A. Wolf, Springer Verlag, Berlin, (1970)

48 J. Brandrup
Polymer Handbook,Interscience Publishers, New York, (1970)

49 H. Saechtling
Baustofflehre Kunststoffe, München, (1975)

Weiterhin standen Informationsmaterialien der folgenden Firmen zur Verfügung:

Angst&Pfister AG, Zürich, CH
BASF AG, Ludwigshafen, BRD
Bieri Blachen AG, Grosswangen,CH
Dow Chemical Company, Michigan, USA
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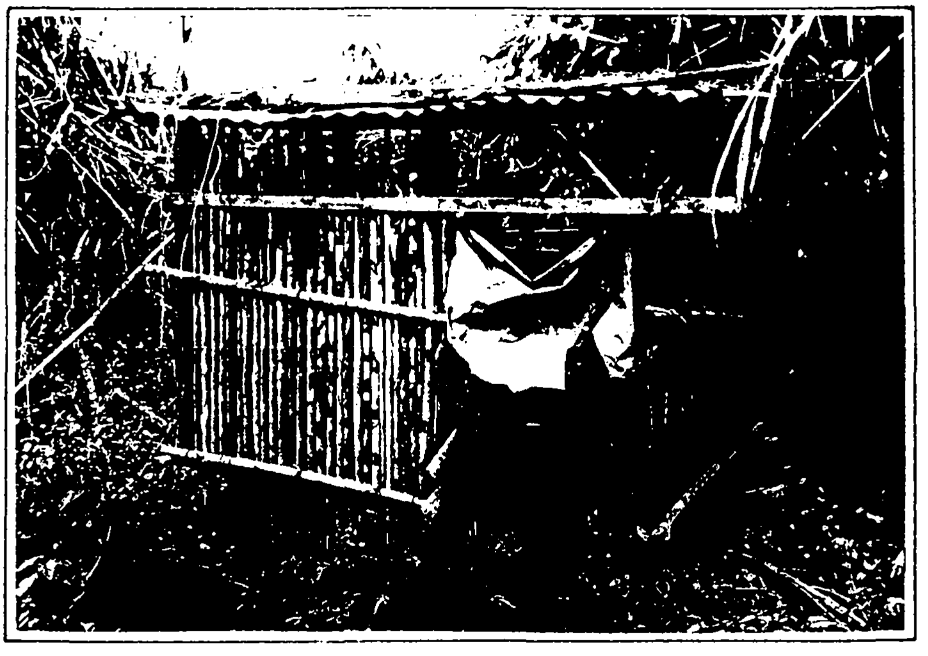
Hoechst AG, Wiesbaden, BRD

11. Latrines

11.1. Selection of type of latrine

11.1.1. The actual situation

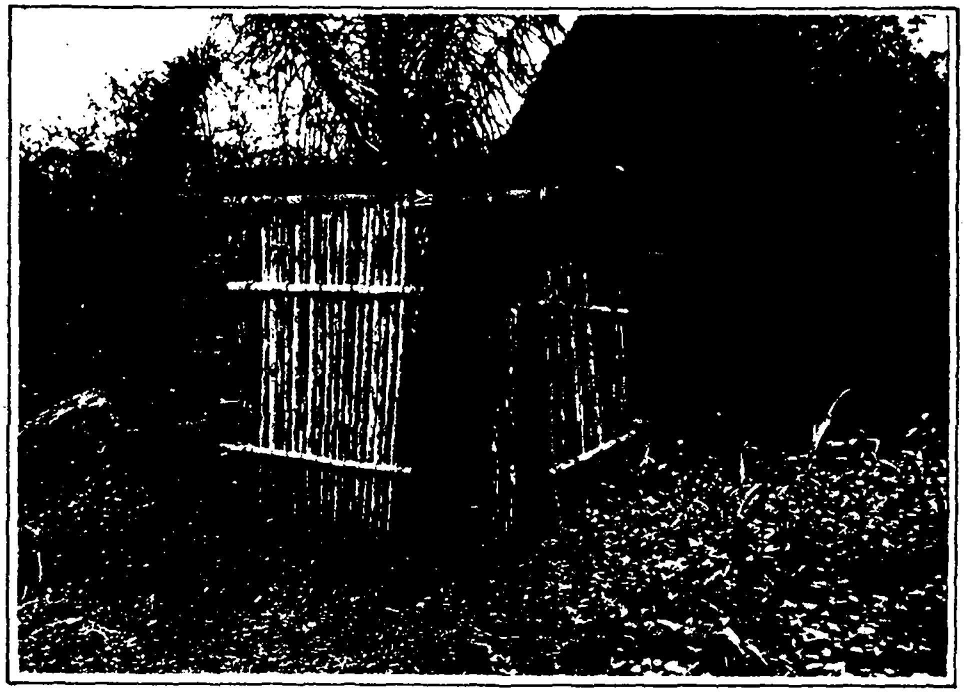
As already mentioned in chapter 6.3.2. the critical point in selecting the appropriate latrine-system is more then anything else the local acceptance. Since in various villages of the Alto Beni area latrines have been constructed and are in use with different success as can be seen from the pictures below, the idea for selection has to be drawn from the actual situation.



The actual situation.

A commen sight:

Abandoned latrines because of colapsed floors remaining as a dangerous trap for children



An exeption:

A reconstructed latrine, which indicates the personal initiative by a villager. At such places the programme has to be sensitively begun namely by promoting such initiatives and improving the design and construction.

of actual situation

ıre obviously conscious about the importance of sanitary ›posal, since they maintain and improve their latrines.

:ied design shows some technical weak parts e.g. floor, ·in some cases bad smell despite intact superstructure.

ɛ preferred to plane squatting slabs.

be known about the danger of contaminating groundwater ɛcal material (liquid) from latrine pits into the ground-

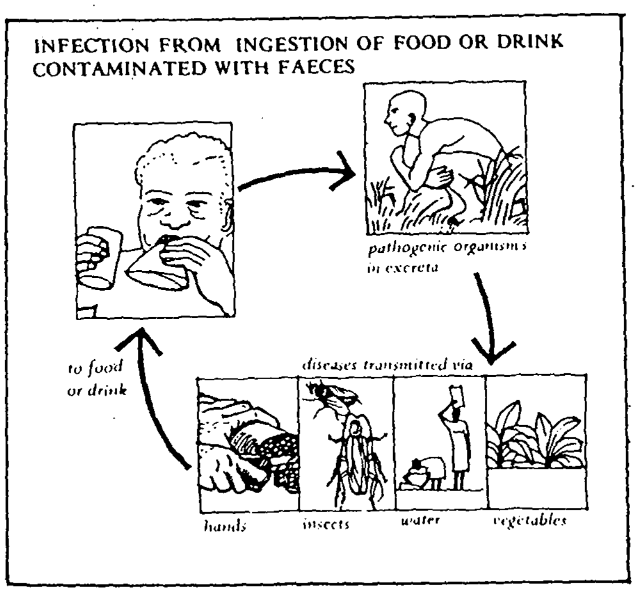
ns from actual situation

n

obviouse that more profound education has to be carried l hygiene requirements as well as on personal hygiene.

f contaminating the groundwater which may be used for oses by pit latrines have to be explained so that the re- the location of pits (see chapt. 11.3) are understood, followed up.

ɛs can play in transmitting pathogenic (disease causing) om infested excreta to new hosts needs to be explained to ;.



liseases

- Interview of villagers

  Villagers still need to be interviewed concerning the following preferences:

  . seat or squatting slab: The seat may be found more convinient, whereas the squatting slab is easier to be kept clean and therefore more hygienical.

  . type of superstructure: The present construction may be preferred to for instance the Zimbabwe designe. But villagers may not be aware about the problem of flies (comp. chapt. 11.1.4.b)

  . pit latrine or pour-flush toilets: In those villages were sufficient water is available e.g. by yard connection pour-flush toilets may be prefered since they are completly free from odour and flies and can be located if desired inside the house (comp. below chapt. 11.1.4.c)

- Designe improvements

  . The collpasing of many cover-slabs of the pits indicates that the cover-slab needs to be improved.

  . Tansmission of pathogens by flies from excreta needs to be reduced by adequate designe of superstructure and ventilation of pits or event. introduction of lids on squatting holes.

  . The bad smell observed may be elliminated by introducing ventilation pipes to the pits.

  . The location of pits needs to be selected according to criterias to protect the groundwater.

- Type of latrine

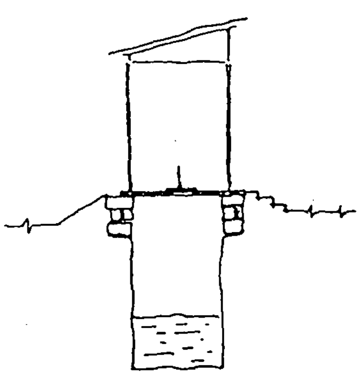
  Pit latrines seem to be commenly accepted. They are considered as an appropriate method since they can be constructed with local available material.

11.1.4. Recommendations

The recommendations given below should be considered as a guideline only.

The choice for a particular design and method of construction for pit latrines depends mainly on the type of locally available material, the level of subsidy provided to make material available which is otherwise not affordable by the villagers, the socio-economic conditions, local acceptance and preferrences and by the soil/groundwater conditions. Considering these aspects an improved minimal standard and an improved optimal standard are recommended below together with a few alternatives for particular site conditions. (Details about designe and construction are provided in the following chapters.)

(a) Minimal standard: The Pit Latrine



This minimal standard is only recommended for family latrines. The improvment to the design applied in D.A.B. area at present consists mainly of a prefabricated floor in form of non-indigenous cover-slab in concrete. This will make the latrine not only structurally safer but also more agreeable to use, prevent the transmission of hookworms and will permit a small measure of fly control through the use of a lid.

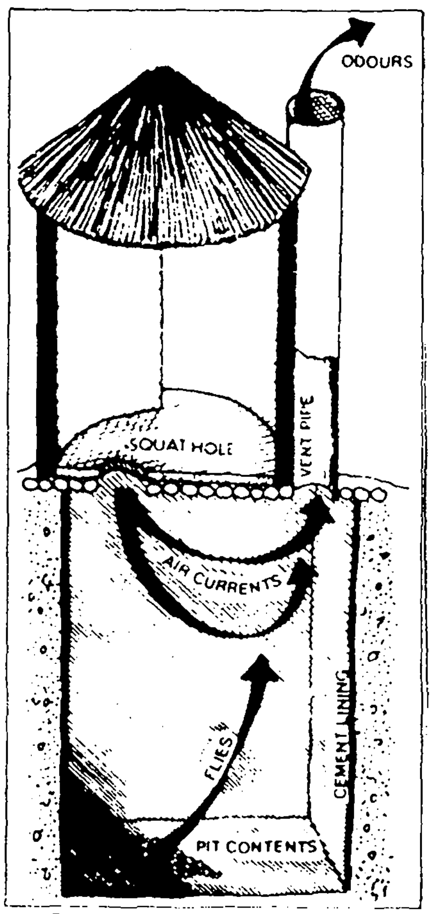
If the above simple desing of a pit latrine is properly constructed through skilled instruction and supervision it can have the following advantages over other types of latrines:

. Except for the cover-slab they can be constructed from locally available material, skill and labour force. They can be therefore realized as a self-help action are quite cheap and can be afforded even by less well-off people.

. Operation is simple and there is no risk of handling relatively fresh excreta containing large amounts of active pathogens (as might be the case in alternating pits or compost type latrines)

. It can function very effectively if well constructed and properly maintained which means kept clean.

(b) Optimal standard: VIP latrine



Airflow and fly movements in a VIP

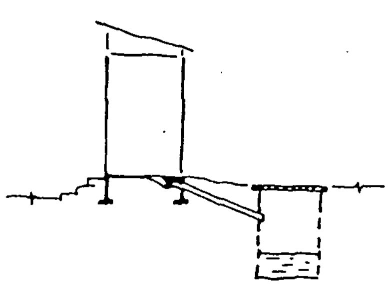
This optimal standard is recommended for family latrines as well as for public latrines (e.g. schools etc.). Inaddition to the above convential pit latrine a ventilation pipe is provided in the VIP-design (Ventilated Improved Pit).

With this measure the two principal disadvantages of the above pit latrine (standard(a)) - namely that it smells and produces hundreds of flies (or mosquitoes) a day - are reduced in the types known as ventilated improved pit (VIP) latrines. Due to the action of wind passing over the top of the vent pipe, the air inside rises and escapes to the atmosphere, so creating downdraught of air through the squatting plate or seat. This circulation of air effectively removes the odours emanating from the faecal material in the pit.

The vent pipe also has an important role to play in fly control. Female flies, searching for an egg-laying site, are attracted by the odours from the vent pipe but are prevented from flying down the pipe by the fly screen at its top. Nonetheless, some flies will enter via the drop hole and lay their eggs. When new adult flies emerge they instinctively fly towards the light; however, if the latrine is suitably dark inside the only light they can see is that at the top of the vent pipe. If the vent pipe is provided with a suitable fly screen at its top, the new flies will not be able to escape and they will eventually fall down and die in the pit. In controlled experiments in Zimbabwe (Morgan 1977) 13,953 flies were caught during a 78-day period from an unvented pit latrine, but only 146 were caught from a vented (but otherwise identical) pit latrine.

(c) Alternative standards

Pour-Flush / Water Seal latrine



Pour-flush toilets have in addition to the convential pit latrine a squatting pan from which the excreta is flushed to a soakaway pit. By careful design of the pan, with a water seal only 15 - 25 mm deep, the very high water demand of the convential cistern-flushed system can be avoided, and the toilet flushed by hand.

If sufficient water is available preferably at a yard connection, pour-flush toilets offer the following advantages:

- low-water-requirements (1-3 l/flush as opposed to 10 - 20 l/flush for most cistern-flush toilets)
- complete odour and fly elimination by the shallow water seal
- they can be located, if desired, inside the house, and not necessarily only on the ground floor.
- being permanent structures not requiring shifting of the installation as is the case when single - pit latrines become filled up,
- requiring shallower depths of receiving pits than pit latrines, making them suitable in areas of high groundwater table or rocky underground.

On the other hand the application of pour-flush toilets is also limited by the following factors:

- Availability of sufficient water in a reasonable distance (yard-tap). Additional consumption of water will amount to about 10 litres per person per day.
- Soakage pits will require normally an alignement because of more liquid.
- If soil conditions are not suitable for disposal to a soakage pit, a two-compartment septic tank has to be provided.
- The use of solid material for cleansing, or careless handling by children will cause blockage and require increased attention and maintenance.

11.2. Subsidy for Pit-Latrines

11.2.1. Some agruments pro and contra

Subsidies for water supplies are justified in their basic rationale by the fact that the construction of improved, piped water supply schemes involves the use of material such as pipes and cement which is neither available in the village nor affordable by the beneficiaries.

Should, therefore, the construction of family and institutional latrines also be partly or fully subsidised?

An argument for subsidiesed family latrine construction (e.g. provision of ferrocement squatting slabs and of ventilation pipes) might be, that most villagers would otherwise not be in a position to construct a latrine for which non-indigenous material is required. It might further be argued that excreta disposal, as an important complementary measure to water supply for achieving health improvements needs to be subsidised as well.

Users of latrines who once have received subsidy for latrine construction from government are likely to seek again such subsidy when a new latrine is to be built or when something goes wrong with the existing system. It is, however, highly questionable whether the government will be able to respond to such demands in future, as excreta disposal takes place in a very disperse-type of infrastructure and therefore would represent an immense task in follow-up and logistics.

Also, as can be easily observed throughout the world (both developing and industrialised), subsidy systems, though often seemingly justified and used to get something going, prove to be detrimental to forces of self-initiation and self reliance, and limit reproduceability of products, structures, processes (such as latrines built with ferrocement squatting slabs, say).
At times, however, subsidy with non-indigenous material or techniques might indeed be advantageous or decided for even where local material and technology would be available, as it might allow for easier construction, longer structural life, or be otherwise beneficial. Yet, subsidising development should generally be limited to components which are of fundamental need and can not be produced or developed from local resources (e.g. pipe material for water supply schemes).

From these arguments the question arises whether or not household (family) latrine construction should be subsidiesed to the user (as are water supply investments). Subsidy might lead to a relatively fast response and a quantitatively more rapid development of improved excreta disposal (in terms of construction, at least, not necessarily in terms of actual usage) because users are attracted by the subsidy. Non-subsidy will probably result in a slower quantitative response but is apt to give the people the feeling that it is their latrine and that it is a technology they can master and reproduce.

11.2.2. Recommendations

a) family latrines:

In a first phase the actual situation has to be carefully analysed. Why do some maintain their latrines while others don't at all? Who has initiated the construction? Was the construction subidised? If yes, what are the effects? The result of this evaluation has to be considered with first priority and the recommendations given below may be considered as guidelines only.

Because of the tropical condition in D.A.B. area it seems that a sufficiently long lasting cover-slab with local material cannot be realized?! If this is the case then the subsidy on pre-fabricated cover slabs is justified. Nevertheless these slabs should not be supplied completely free of charge but they should be sold on a small affordable amount. In order to avoid wastage only those buyers may be considered, who have already dug the required pits and kept the material ready for the superstructure. In case an improved superstructure cannot be afforded by the majority an additional subsidy may be provided to those families, who have completed their latrines to an acceptable standard.

VIP-latrines for family usage may be substisised, if the beneficaries realy understand the advantage and demand such a health improvement. It is advisable to construct VIP-latrines in a first phase only for public latrines.

It is obvious that above remommendation restricts the system choice to simple convential pit-latrines (standard a). Though this can be called a minimal solution, it can give satisfactory performance and be structurally and hygienically safe. Most important: This system requires minimal input from outside and therefore villagers will find it more easy to identify with it.

b) public latrines: (for schools, health posts etc.)

Such latrines require a somewhat more sophisticated designe and method of construction because of expectedly heavy use and lack of proprer care and maintenance. That's why the VIP latrine design is recommended for this purpose. Subsidy for public latrines should therefore encompass the following items:

. squatting and pit cover-slabs
. ventilation pipes
. event. timber for roofs and door frames
. roofing material
. skilled and semi-skilled labour

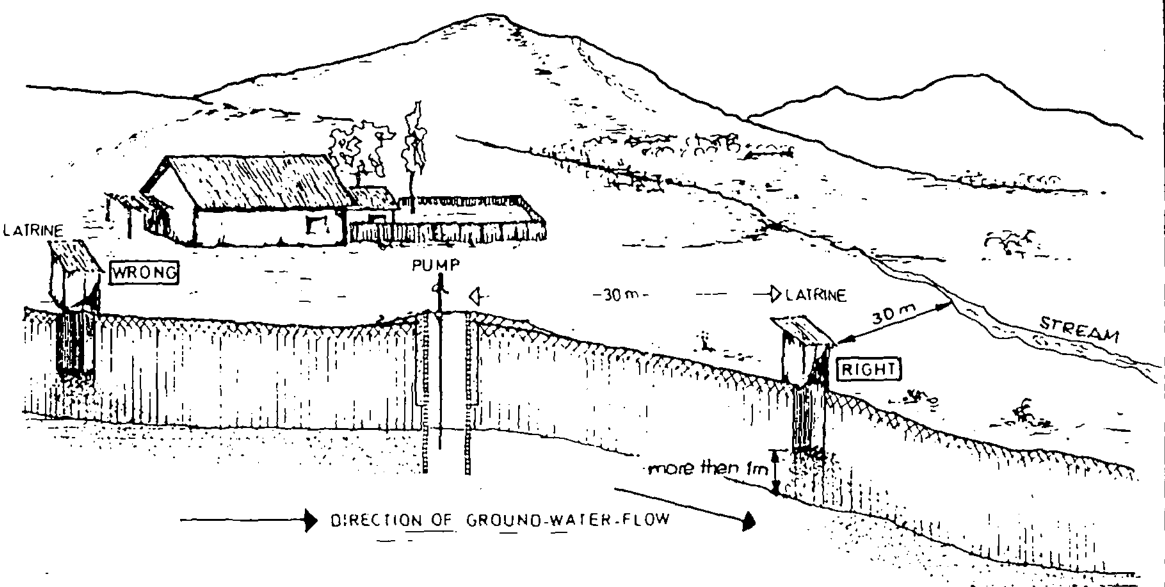
11.3. Location of pit latrines

The aim of pits is to provide a safe place for excreta to decompose as well as for liquids to soak into the surrounding soil. That's why the installation of pit latrines will always involve the risk of contaminating the groundwater or neighbouring surface waters.

In order to meet with above prerequisites and to avoid any harmful contamination the following basic requirements must be considered when determining the location of pits:

- The pit should not be installed within a radius of 30 m from any well, drinking-water reservoir, stream etc.
- In order to avoid the contamination of drinking water due to groundwater flow, pits should never be placed up-hill (up-stream) of any drinking-water well or source catchment.
- For hygienical reasons the pit should not be nearer then 8 m from the nearest dwelling.
- For the sake of convenience, the privy should be no farther than 30 m from the building to be served.

- The bottom of the pit must be at least 1 m above the groundwater level during the wettest season of the year, so that pathogenic organisme may not enter the groundwater.
- The bottom of the pit must be at least 1 m above impervious layers creviced rock, hardpan, shale, or clay.



criterias for the location of pit latrines

- A pit should be dug in permeable soil. Suitability may be checked by a test hole. As a general guidline the chart below may be helpful.

Soil Suitability

Soil Type	Suitability
Sand	No [1]
Sandy Loam	Yes
Loam	Yes
Silt Loam	Yes
Clay Loam	No
Clay	No

1) If no alternative is available, lining of pit walls is required!

11.4. Determining Pit Size

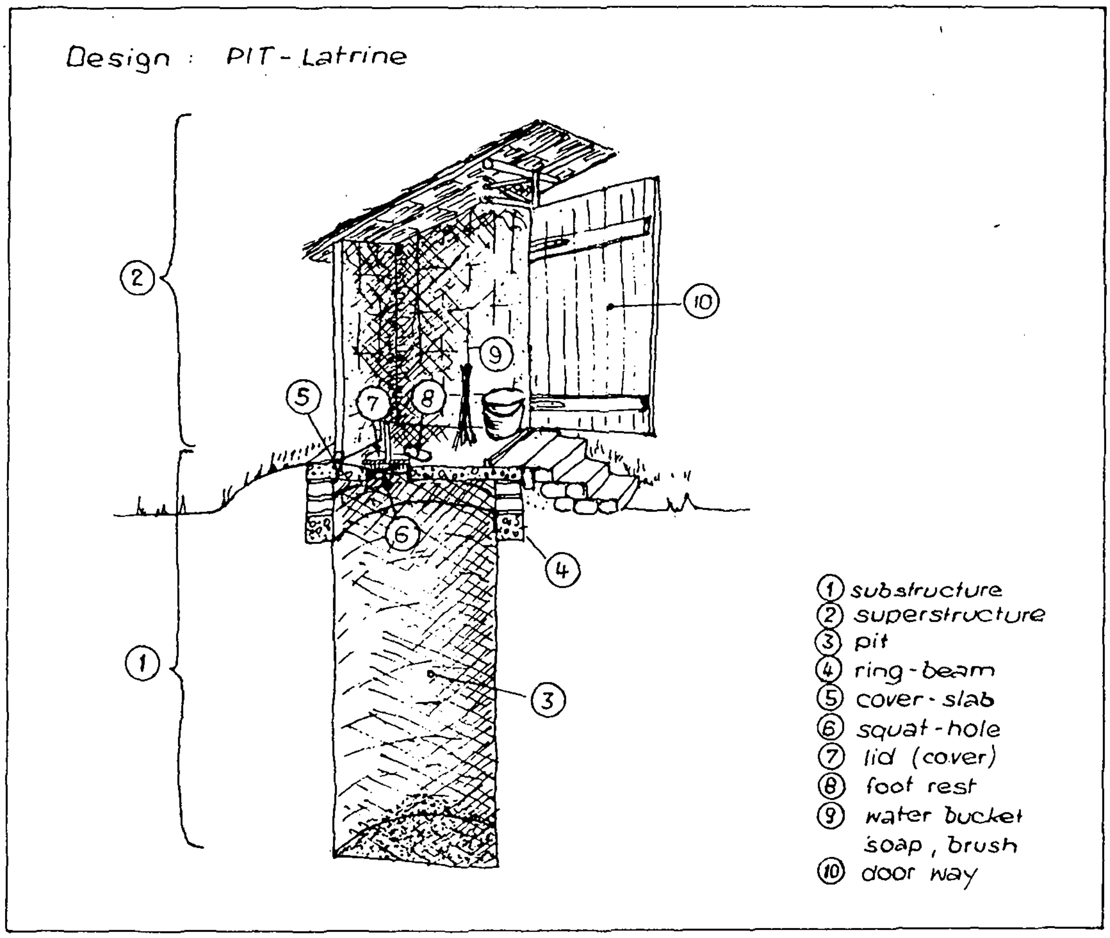
The pit should be as large as possible. The required capacity, or volume, of a pit is determined by the number of users of the privy, the number of years the pit is expected to last, the standard of the pit (conventional or pour-flush) and the type of anal cleansing material used. The resulting quantities will naturally vary very much from country to country, in accordance with food habits and quantity of water available. The figures given below can be taken as a guideline. Annex VIII shows a sample calculation of the size of the pit.

- The number of users equals the number of persons living in or using the building to be served
- The pit should be designed to last 5 to 10 years
- In case of a convential pit latrine the volume should be at least 0,06 m3/person for every year of anticipated life
- In case of a pour-flush latrine the volume can be reduced to 0,04 m3/ person year, because excreta, which stands under water, decomposes more rapidly.
- The theoretical volume resulting from above factors needs to be increased by 50 % where bulky materials, such as stones, maize cobs, or cement bags etc. are used for anal cleaning.
- At the top of the pit 0,5 m must be spared, since the pit must be filled with earth before it is completely full
- For safety reasons the depth of the pit should normally not exceed 3,5 metres depending on the soil condition. For the same reason round pits may be prefered to rectangular ones.

It is obvious that the dimensions of the pit in particular its depth have to correspond with the prerequisites defined in chapter 11.3 useful hints are provided in Annex IX., if alternative solutions become necessary.

11.5. Design and Construction

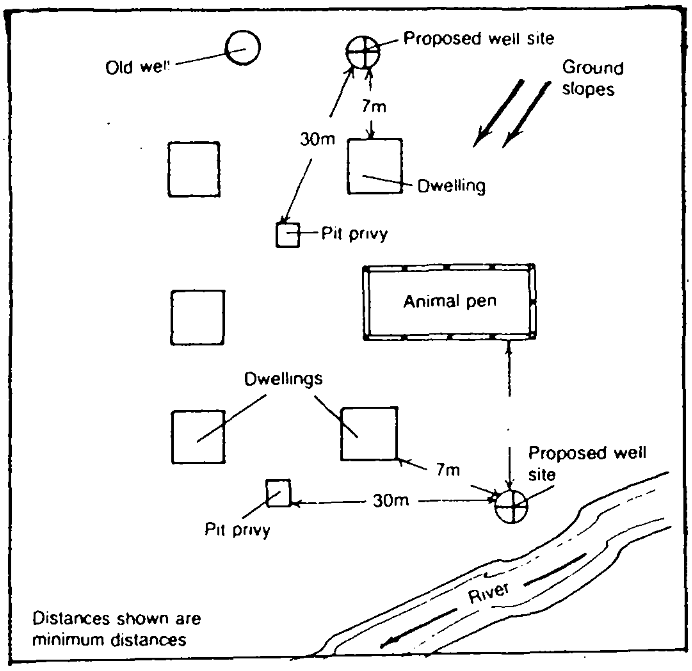
The recommendations given below should be considered as a starting idea to find out and develop appropriate designs and construction methods of latrines. Ref [2] and Ref [26] may be consulted in addition.



11.5.1. Preparation work

When the appropriate and accepted standard and design of the choosen latrine have been decided about, the project designer has to prepare the following two items:

1. Location map



similar to the sketch beside, showing the correct location (comp. chapt. 11.3) where the pit is to be excavated. According to this map pits should be located and pegged at the site.

2. Construction Manual (comp. Annex X)

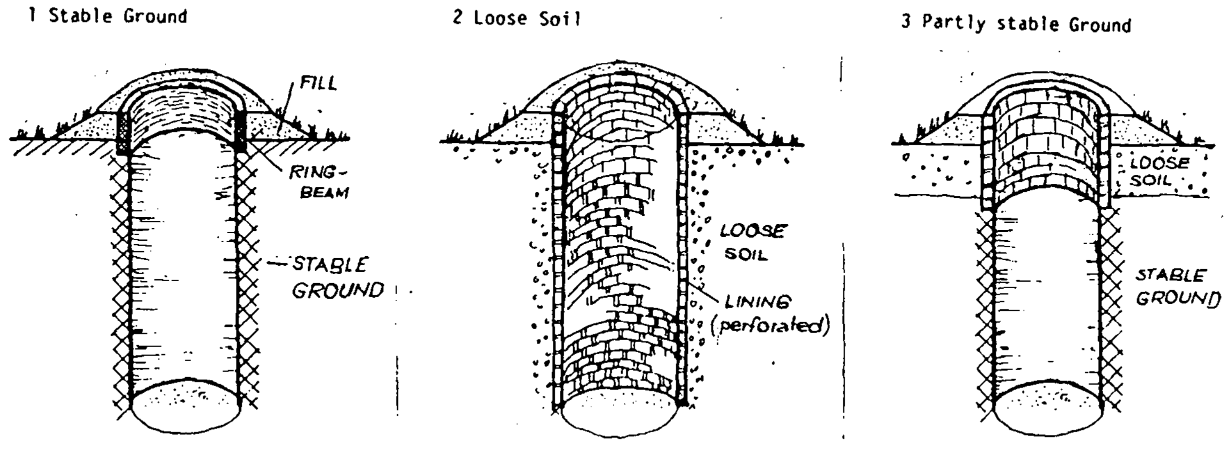
It is most essential to prepare a simple, well illustrated construction manual which can be easily understood by the villagers. This manual should include the following items:

- list of material required (incl. where it can be obtained if required)
- drawings for the construction of the pit, cover-slab and superstructure
- instructions about the different steps of constructions and cautions to be taken.

11.5.2. Design and Construction of Pit

The determining of the size of the pit has already been shown in chapt. 11.4. It has also been explained that round pits are to be prefered to rectangular ones because of higher soil stability.

Different designs of pit-constructions



Excavation:

Excavation has to be done exactly at the location which has been selected according to the criterias described in chapt. 11.3. Depending on the soil condition the walls must be shored during excavation to prevent cave-in that could be fatal to the worker in the pit. Digging must be done to the dimensions specified by the project designer to protect groundwater etc. and other sources of drinking water. Caution should be taken to cover the pit when it is not attended during the construction phase.

The earth removed from the pit has to be evenly distributed around the pit (ring-beam) so that the floor of the latrine gets elevated against the surounding. In this way surface runoff can be prevented from entering the pit.

Lining:

A lining is particularly important in loose soils or where the pit will be full of water, but should not prevent the seepage of fluids into the ground. The material for the lining if required can be bamboo, logs, poles, bricks, concrete blocks or select field stones. That material should be considered which is readely available and with which laborers are familar.

In many cases only the upper part of the pit may require lining. In other cases where the soil is very stable lining may not be required at all.

Ring-beam:

In any case it is adviseable to construct a ring-beam around the upper part since this will strengthen the pit against collapse as well as provide a base for the cover slap and superstructure. This ring-beam can be constructed in brick- or stone-masonry or in concrete. A possibility is to excavate carefully a trench ca. 20 x 20 cm according to the shape of the pit before excavation is started and to cast the ring-beam in situ.

11.5.3. Design and Construction of Cover-Slab (Squatting-Slab)

The cover slab must be strong enough to support the weight of the superstructure and weight of the user. The cover slab should be flush with the outer edge of the foundation (e.g. ring-beam), which means elevated against the surrounding area. The slab can be made from rot-resistant timber which is covered with soil and then mortared, with conventialy reinforced concrete, ferro-cement-concrete or even non-reinforced concrete (comp. drawings below). As it has been already discussed before the technicians have in the first instance to find out why so many cover-slabs at the existing latrines have colapsed. Depending on the outcome of this evaluation it has to be decided which cover is most appropriate (sufficiently long lasting = at least for the periode the pit is designed for).

Any of the cover-slabs selected has to have a smooth and easy-to-clean surface.

The location and size of the hole for the excreta to pass depends wether a sitting or squatting posture is preferred for defecation. Seats may have the disadvantage of being difficult to be kept clean and reduce hygiene. Nevertheless if they are more acceptable by the population they may also do their job if properly designed and if the people are well instructed. (It may be helpful to constructe different designs (with seats and squatting slabs) so that the population can define their preferences.)

If the squatting posture is accepted, it is important that the surface of the cover slab slopes (5 %) towards the squate-hole in order to provide drainage for urine and the water used to clean the cover slab. Just so foot-rests should be provided in the correct position, so that they help to locate the user directly over the squat-hole and so minimize fouling of the cover slab with excreta.

Examples of Prefabricated Squatting Slabs

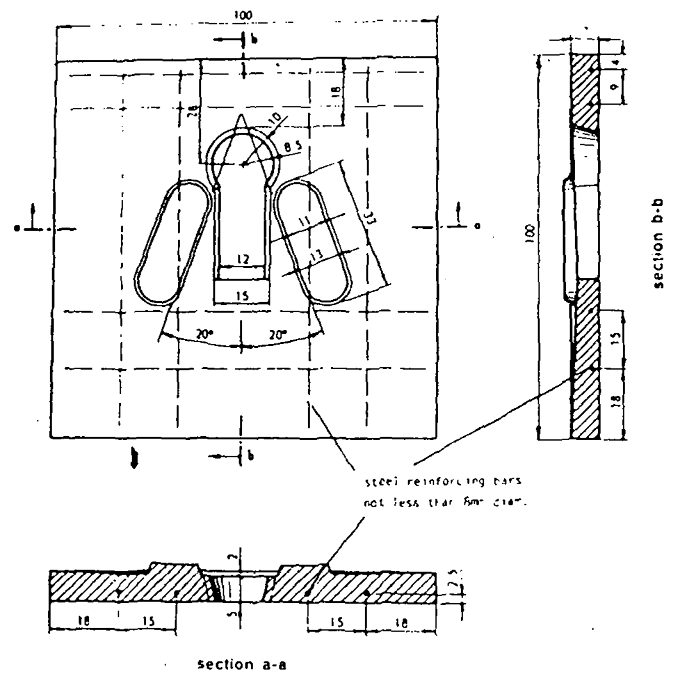
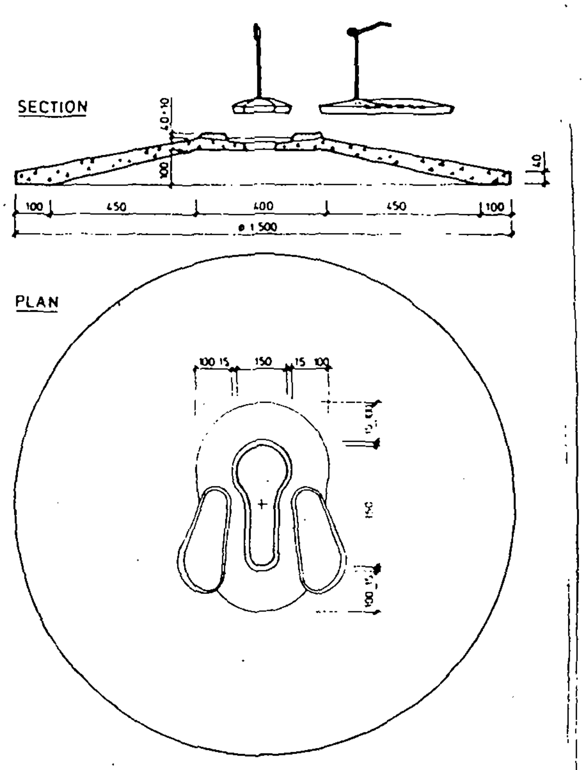


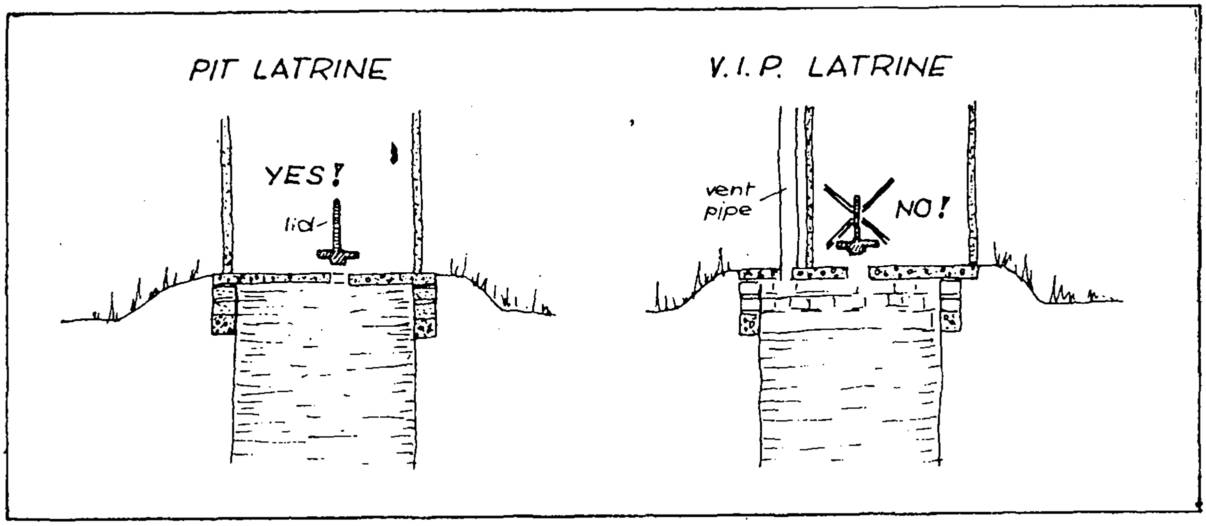
Figure 8.1 Square reinforced, concrete squatting slab for a pit latrine (dimensions are in centimetres)
Source: From Wagner and Lanoix (1958)



Engineering drawing of the Mozambican non-reinforced latrine slab
Dimensions in millimetres

11.5.4. When to provide a cover (lid) over the squat-hole

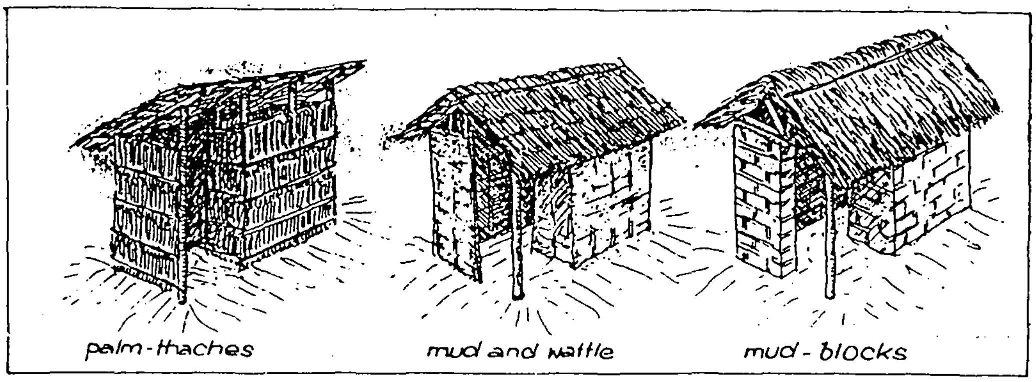
It is important to understand the difference in the functioning of a convential pit latrine and a VIP (ventilated) latrine. While it is essential to cover the squat-hole in case of a pit latrine this should never be done in case of a VIP-latrine, because it would prevent air from entering the pit so that the required air-circulation could not take place. (comp. chapt. 11.1.4 and 11.5.6.)

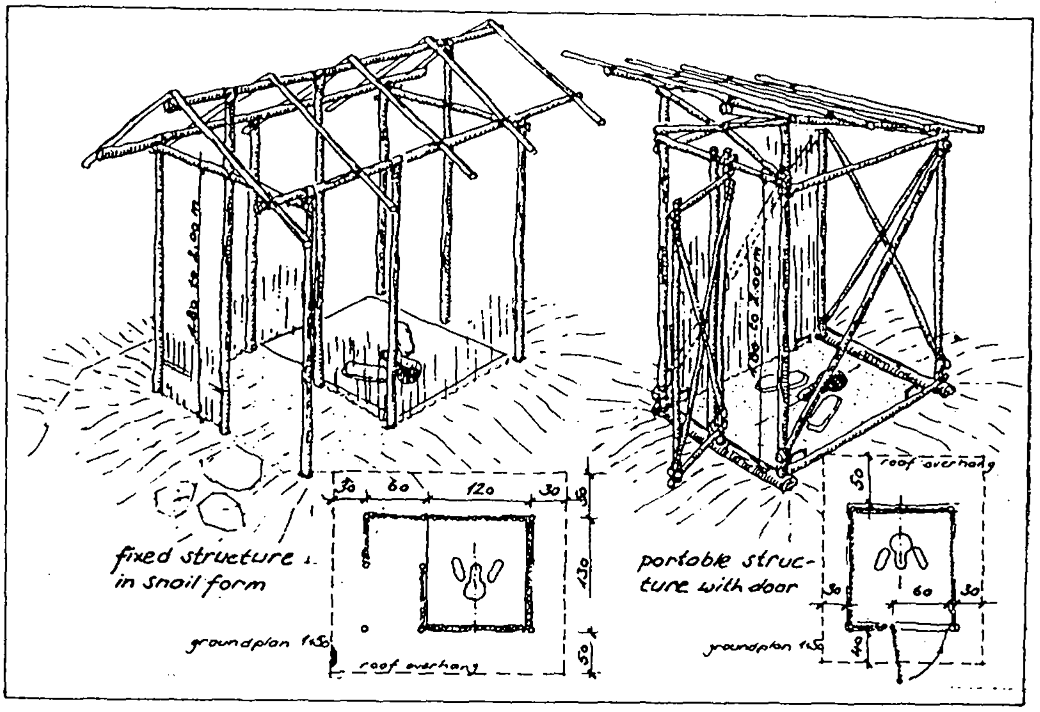


In case of a convential pit latrine it is essential to provide a light tight-fitting lid of solid timber or high quality concrete. This should not only prevent flies from entering but also stop the smell.

11.5.5. Designe and Construction of Superstructure

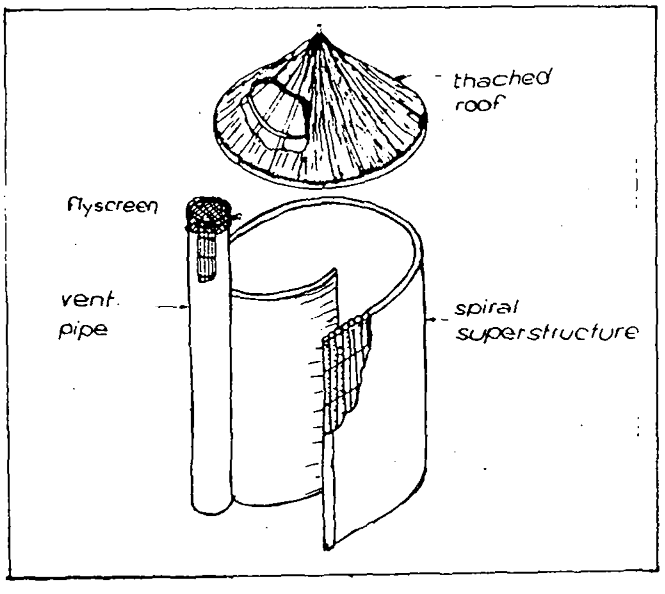
The function of the superstructure of any type of latrine is to provide the user with privacy, comfort and protection from the element. The superstructure can be built in a wide variety of forms and in a wide variety of materials.





Traditional housebuilding skills should be applied so that the householder knows how to repair the superstructure himself. The latrine superstructure should have an area of about 90 x 100 cm. The height of the roof at the level of the entrance should be about 2 m.

The entrance can be provided by a doorway or in by passing a sight-protection wall (e.g. in a spiral shape like the Zimbabwe-design). It is very important (for fly control) that the door remains closed while the latrine is not in use. Self-closing doors can be simply constructed by a counterweight attached to the top of the door via a rope and a pully.



11.5.6. Designe and construction of the VIP-Latrine (Ventilated-Improved Pit-Latrine)

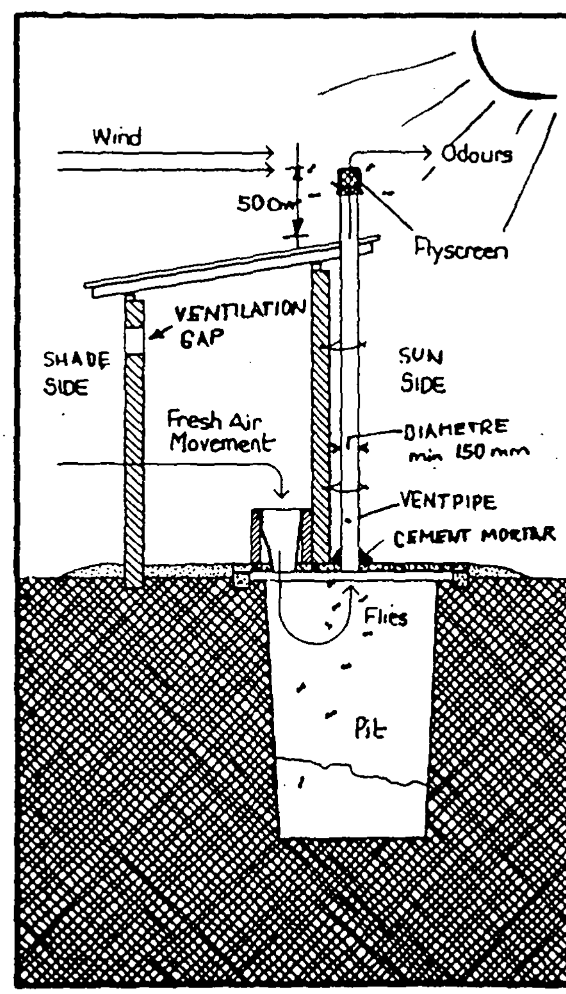
comp. Ref. [26]

The functioning and advantages of the VIP's have already been explained in chapt 11.1.4. Designe and Construction of VIP's are very similar to the one of convential pit latrines. Nevertheless certain aspects need to be considered in addition for some of the elements of a VIP as described below.

- As an alternative two pits may be provided which are used alternately. The size of each pit should be such that it can carry the excreta of at least twelve months. In this way desludging of the first pit has only to be done twelve months after closing, so that the health of the person carrying out the operation is sufficiently protected.
- The cover-slab requires beside the squat-hole an additional one for the vent pipe. Since the vent pipe should be installed outside the superstructure but still over the pit it is essential to construct the superstructure slightly away from the center of the pit (comp. sketch below).

The ventpipe serves a dual purpose. First, it carries foul air out of the pit and away from the superstructure. This occurs mainly because wind blowing across the top of the ventpipe sucks foul air out of the pit. Ventilation also occurs on still days when the sun heats the air in the ventpipe, causing it to rise. Second, the ventpipe serves as an insect trap. Flies and other insects will only fly into the light. As a result, provided the superstructure is kept reasonably dark, insects will travel out of the dark pit up the ventpipe. However, when they get to the top of the ventpipe, they are trapped by the flyscreen, and they eventually die and fall back into the pit. The flyscreen also keeps insects from entering the pit through the ventpipe.

The ventpipe may be either polyvinyl chloride (pvc) or cement-wash hessian (see Appendix X), depending on the funds available (i.e., the hessian type is much less expensive) and on the location of the village. A plastic-coated glass-fibre or stainless-steel mesh flyscreen must be secured to the top of the ventpipe with galvanized wire or a pipe clamp.



- The superstructure of a VIP has two additional functions to the one of a pit-latrine which need to be carefully considered in the design and construction:

  a) to provide sufficient shade over the squate hole so that newly emergent flies are not attracted to leave the pit via the squat-hole;

  b) to channel air through the squat-hole and up the vent pipe, in order to control both flies and fecal odors.

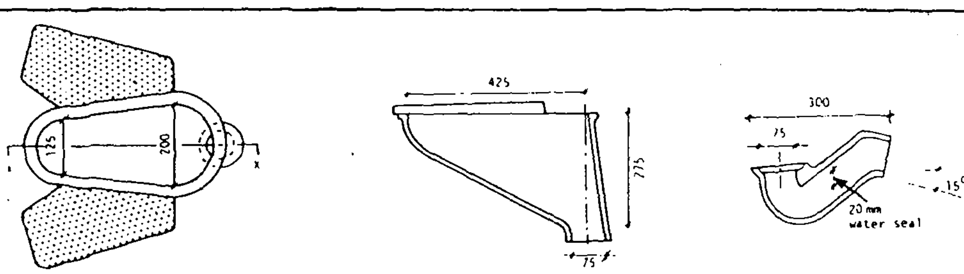
11.5.7. Designe and construction of the Pour-flush latrine

The operation and advantages of the pour-flush latrine has been explained in chapter 11.1.4. Ref. [26] gives very profound instructions about design, construction and maintenance.

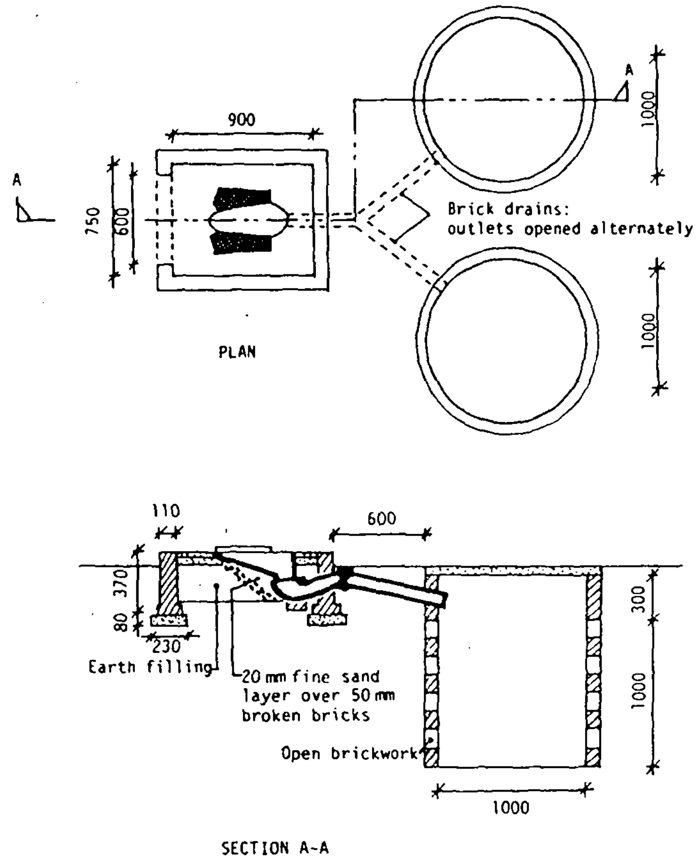
The aspects which need to be considered differently for the various elements of a pour-flush latrine are described in brief below:

- As in the case of VIP-latrines, probably the better long-term solution is for pour-flush toilets to have two pits. Since more liquid is flushed into the pits an alignment of the pits is adviseable in any case. The size of the pits may be reduced since decomposation goes quicker under water (comp. chapt. 11.4.)

- The squatting pan can be of ceramic, glass-fiber reinforced plastic (GRP), PVC, HDPE, mosaic or cement concrete. Ceramic or GRP pans have many advantages over the concrete ones. They are smooth, require less water for flushing and are more aestetic. Though concrete pans may be initially less expensive they are not recommended in case pour-flush latrines are constructed in D.A.B. area.



Pour-flush squatting pan and trap developed by the Indian Standards Institution (dimensions are in millimetres) (Drawing: A K Roy)



Twin-pit pour-flush toilet developed by the World Bank/UNDP Technology Advisory Group for urban sanitation projects in India (dimensions are in millimetres) (Drawing: A K Roy)

11.6. Difficulties with Pit Latrines

The principal areas in which difficulties are encountered in the construction and operation of pit latrines are the following:

- rocky ground
- sandy soil
- high water table
- water contamination.

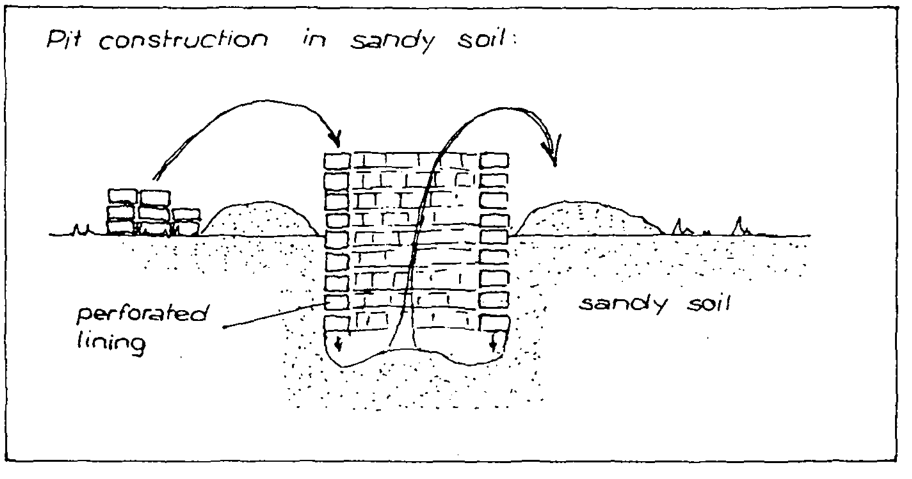
Ref.[2] provides useful informations on this topic. A summary is given below.

- Rocky ground:

  There is no easy answer to this except that householders in such areas require definitively assistance from outside, because of high cost and difficult work. Provision of twin-pits which are used alternately is essential. But their sizes have to correspond with the excreta volume of one year, so that excreta does not need to be handled before it has decomposed for twelve months.

- Sandy soil:

  Lining, of the pit is required. It has to be done in such a way that faecal liquors can still seep into the surrounding soil. It may be essential to build up the walls of the pit on the ground and to sink them into the ground by removing the sand inside the construction. In this way no caving in can take place and laborers are protected.

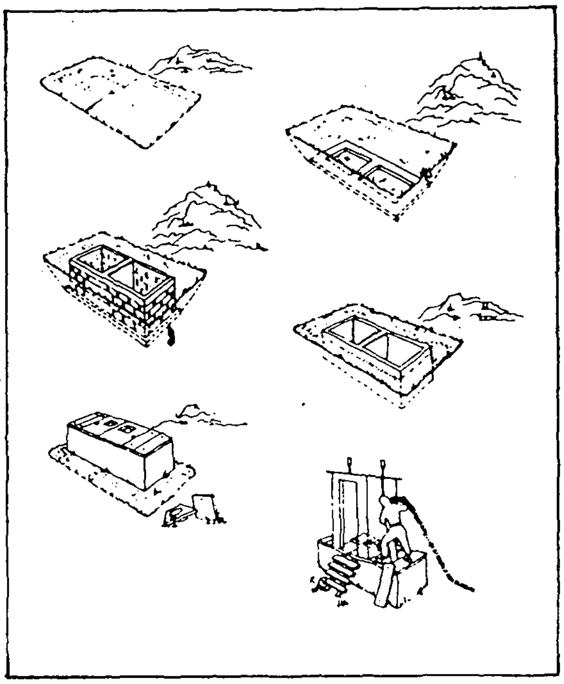


- Water contamination:

  The placing of wastes in pits will always present the danger of polluting water sources-particularly wells located nearby. Measures which need to be taken and followed up have been described in chapter 11.3.

- High water table:

  In such circumstances a built-up pit is appropriate (comp. drawing below). The built-up plinth may be about 1 m high and the impermeable lining should extend down at least 0,6 m below ground level.



11.7. Operation and Maintenance

In the same way as for the construction of excreta disposal facilities, thought must be given to a clear division of responsibilities between the sanitation agency and the users with regard to their maintenance. It is obviouse that in case of D.A.B. as much as possible the users will be directly involved in the required operation and maintenance work (comp. chapt. 11.2.). Nevertheless frequent supervision and in particular instructions and education will be required by skilled personel.

Since Ref. [2] deals with this subject only some of the important points are summarized below.

11.7.1. Operating a Pit latrine

- Keeping latrines clean is of the utmost importance for hygienic conditions. The following measures should be followed up
  . daily washing of squatting-slab, squat-hole or seat with brush (use soap or sprinkle ashes)
  . in case of pour-flush toilets, water must be always readily available (keep a bucket in the shelter); pour enough water; do not use any material for cleansing which could block the water seal;
- Fly control is most important to get at efficient health improvement
  . The lid has to be put back after every use in case of a convential pit latrine
  . the entrance door has to be closed also after use
  . the superstructure is to be maintained so that the interior remains shady
  . after each use a small can or coconut shell may be used to sprinkle ashes through the squat-hole
  . pouring insecticides into the pit to kill flies is not recommended.
- In order to get the pit not filled up to quickly only materials which easely decompose should be used for anal cleaning (avoid bulky materials like stones, maize cobs, cement bags etc.)

11.7.2. Repairing a Pit latrine

The entire construction should be inspected ones a month. Required repairs should be undertaken immediately, so that high costs can be avoided. In case a lid is in use make sure of proper closing.

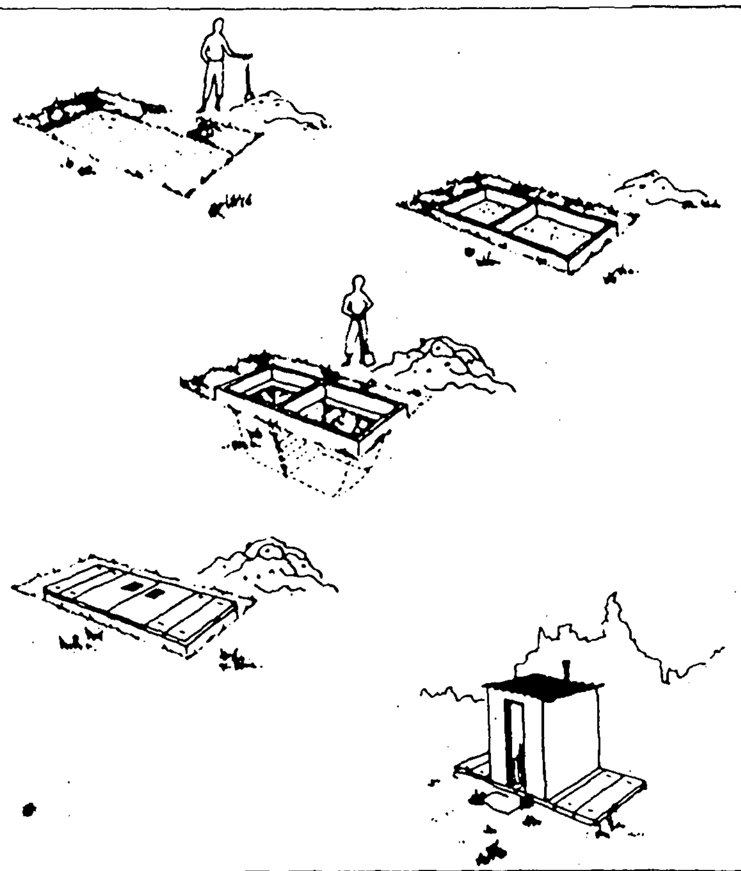
11.7.3. Moving a pit latrine

When the contents of the pit reach 1,0 - 0,5 m below the squatting slab, preparations for a new pit have to be made. The site, size and dimensions of the new pit should be determined by the responsible sanitation officer.

When the contents of the pit are within 0,5 m of the squatting slab the pit must be abandoned. Depending on the condition they are in, the slab and shelter may be used for the new latrine. The old pit has to be filled up at once and mound about 0,6 m to allow for settling.

11.7.4. Alternation of pits in case of twin-pit latrine

As already discussed above it can be more convinient and possibly less expensive to design a twin-pit VIP latrine of the type shown below. In this version one pit is used for a given period (at least twelve months) until it is full, when the second pit is put into use. The first pit is only emptied and used again when the second pit is full. Thus the excreta are never handled until they are at least twelve months old, when only a few Ascaris eggs at most will still be a live. No other materials are added to the pits, which both act as normal leaching pits.



5 Construction of a twin-pit VIP latrine
Source: After Carroll (1980).

11.8. Administration and Organisation of Latrine Programme

Differently to a drinking water supply scheme villagers are normal not so enthusiastic about latrine- and health hygiene programmes, because the need for these improvements are not that obvious. For this reason the organisation of latrine- and health hygiene programmes need to be planned very well.

This includes the following aspects:

- content and policy of the programm
- setting up of the programm
- the programm team
- implementation at village level

Ref. [26], especially the "TAG Technical Note number 9: Handbook for District Sanitation Coordinators" which is written on practical experience in Botswana provides most useful informations and recommendations. The two "contract-forms" shown below are an example on how the responsibilities can be shared at household-level.

Appendix V

Handout C — Building Your Own Latrine

Here is how you can build your own latrine with the help of the District Council

1. First, you will be required to pay P ______ for the materials that Council will bring to you. Half of the total payment, P______, must be paid before 1st July. The second half, P______, must be paid by 31st August
2. After you have paid the first half, the Village Sanitation Assistant will visit your house and, with your help, construct a concrete ringbeam. When this is done, you will have to dig the pit. When the pit is finished, you should contact the Village Sanitation Coordinator in your village and he will send the Village Sanitation Assistant back to your house. Then, with your help, the Village Sanitation Assistant will place the slabs over the pit and build a foundation for the superstructure with the mud (or concrete) bricks you have made.
3. Following that, it will be time for you to build the latrine superstructure and put the roof on.
4. After the second payment is made, the Village Sanitation Assistant will bring your ventpipe and seat insert and help you install them

See how easy it is to build your own latrine. This offer is only good for this year. Next year, the programme will move to another village

____

(District Sanitation Coordinator)

Appendix VI

Householder's Latrine Contract

I ______________ of ______________ village, ______________ District, agree to pay the sum of ______ Pula to the Council Revenue Officer

In return for this fee ______________ District Council will provide me with:

a) 3 latrine slabs

b) 1 ventpipe

c) the technical assistance necessary to construct my own latrine

d) 1 3-metre piece of Typar

e) 1 3-metre piece of wire mesh

f) labour and materials necessary to install a reinforced concrete ringbeam

(Delete that which does not apply)

The terms of payment will be ______________________________

____

Signature of Home Owner ______________ Date ______

Signature of Headman ______________ Date ______

Signature of Council Secretary ______________ Date ______

source : TAG Nr.9

12 Summary

Above working paper should be a useful tool for the engineers, technicians and sanitation-coordinators[1)] in charge of the drinking water supply and excreta disposal schemes in Alto Beni area. Though the paper deals mainly with the technical aspects it tries as much as possible to show at the same time the links to the basic objectives of the programme. Experiences on failures and successes at similar programmes indicate that this view is an absolut necessity, if the programme should have any long term impact on the community concerned.
- Intentionally the paper starts in each chapter from the actual situation and tries than sensitively to guide to possible solutions. No recipes are provided but hints and recommendations are made so that the people directly concerned can make use of their responsibility and initiative to take the adequate decisions.

In order to provide a quick overlook for the fast reader a brief commentary is given below to each chapter.

- Chapter 1 introduces about the aim of the working paper including its qualification.
- Chapter 2 points out the role of above programme, which is mainly to build up the confidence of the villagers concerned into the complexity of the entire D.A.B. programme. That's why the idea of self-reliance and self-help has to be the basic policy in the different phases like planning, implementation, operation and maintenance.
- Chapter 3 explaines why the software-[hygien - and health education]- is as important as the hardware-[technic]- in aiming at health improvement. In its consequence the required personel as well as adequate moral and financial support have to be provided to cover the software.
- Chapter 4 shows the ways and means to find the appropriate technical solutions, which should be a sensitive compromise of the historical know-how of the villagers concerned (tradition) and the basic principles of the technology.

1) see Ref 26 TAG Nr. 9

- Chapter 5 informs about the fact that sufficient quantity of drinking water in a reasonable distance is at least as important as its safe quality for the effectiveness of health improvement.
- Chapter 6 indicates that the complexity of the project - the software as well as the hardware component - needs already to be considered in the stage of preliminary survey and feasibility study.
- Chapter 7 defines that the main criteria in the selection of water supply systems is that it is designed for the simplest possible maintenance requirements, which in turn can be handled as much as possible by the consumers themselves.
- Chapter 8 provides practical informations about design and construction criterias. Reference to relevant manuals etc. are made where ever possible and additional hints are given including illustrations where required.
- Chapter 9 suggests the most appropriate material and methods to be applied for the construction of above water supply projects in taking in consideration the locally available material, skill and transport.
- Chapter 10 underlines the importance of adequate operation and maintenance which is more difficult to realize than the implementation of the project itself. That's why serious attention needs to be paied to this aspect already in the planning stage. - Since water for domestic use is women's business ... women have to play an important role in water supply projects.
- Chapter 11 covers the aspect of safe excreta disposal which is as important as safe supply of drinking water for health improvement of a community. Simple designs of latrine construction are discussed and recommendations are not only made about the technical solutions but also about a limited subsidy of the programme with a clear asignement of responsibility to the householders concerned.

Finally it has to be underlined ones more that above paper is a working paper and as such it is to be used as a guideline for the implementation and as a base for further discussions.

St. Gallen, July/August 1985

K. Wehrle
SKAT