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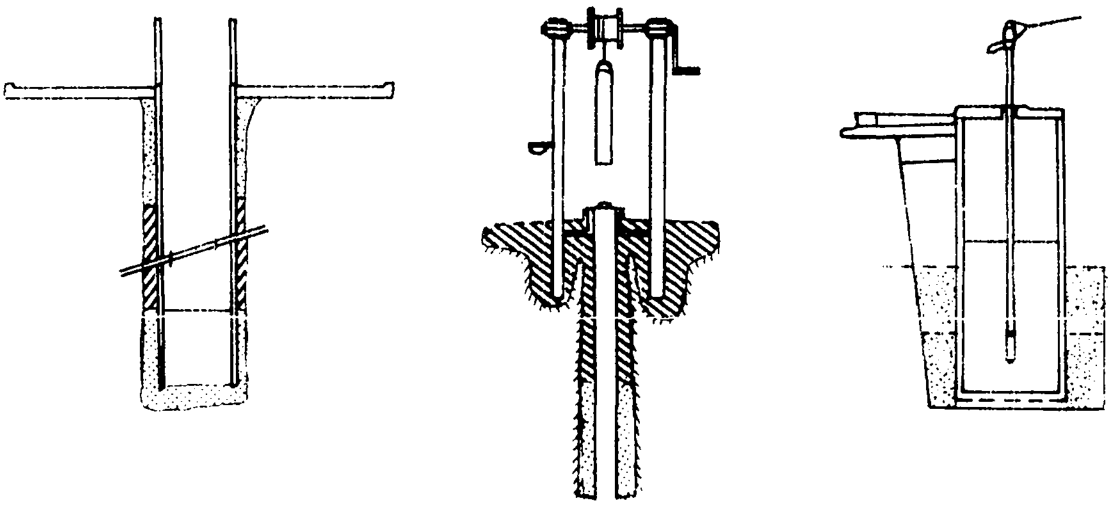
Wells in Developing Countries
Workshop Report



Tampere 1985

WELLS IN DEVELOPING COUNTRIES

Report on the Workshop held 23 Jan 1985
at Tampere University of Technology (TUT)

Edited by T.S. Katko

June 1985

WELLS IN DEVELOPING COUNTRIES

WORKSHOP 23 JAN 1985

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WELLS IN DEVELOPING COUNTRIES

Workshop 23 Jan 1985 at Tampere University of Technology (TUT)

LIST OF PARTICIPANTS

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Prof. Matti Viitasaari
Tampere University of Technology (TUT)

OPENING SPEECH

As a part of the course programme we are used to having seminars every Thursday morning where two participants present their papers followed by discussion. These seminars have proved to be useful and interesting.

In addition to the seminars last November we had the first workshop dealing with ground water exploration. In principle, the workshops have covered the topics of high importance. This time the workshop on wells was preceded by a group work through which the students had possibilities to present their views and opinions on different matters. Today we will hear reports based on this groupwork.

Finally I want to welcome all the visiting experts, university staff and the course participants to this workshop and wish you an interesting day with lively and fruitful discussions.

Mr. Pentti Rantala, TUT, chairman
Mr. Tapio Katko, TUT, editor

CONCLUDING REMARKS

Based on presentations and discussions during the workshop the following conclusions can be drawn.

1) Funding limitations, operation and maintenance as well as lack of professional manpower were regarded as the most severe constraints in rural water supply by the Ethiopian, Kenyan, Tanzanian and Zambian participants.

2) In regional water resources development it is a good way to begin with inventory of ground water deposits. In Kenya use of wells for community water supply is starting to go through.

3) In operation and maintenance incentives should be introduced to water users and maintenance personnel. Ways for getting at least partial cost recovery should be carefully considered.

4) Ground water compared with surface water is safer and in many ways better source for drinking water production. In developed countries aquifers are often used for artificial recharge and quality improvement. In African conditions the river bed deposits could be used for artificial recharge or infiltration.

5) In Finland surface waters were regarded as the most important sources for municipal water supply up till 1950's. Thereafter the interest towards ground water utilization has grown so that at the moment almost 50 % of our drinking water comes from ground water sources. Wells have been constructed since ancient times and that experience and knowledge could be taken more into consideration.

6) In well siting users' wishes and traditional knowledge on reliability of sources should be taken seriously into account. To find out these wishes we have to know the channels through which to communicate. However,

peoples' knowledge is limited to shallow or perched aquifers. The laws of nature govern the occurence of ground water and therefore, the use of hydrogeology is of utmost importance in well siting, especially for deeper aquifers.

7) The key issues in management of rural water supply project are how to organize construction and how to organize operation and maintenance. In Mtwara-Lindi rural water supply project the responsibility of hand pump maintenance is gradually transferred to villages. The pump attendant gets his payment from the village. In most cases there exists properly working administration in villages and this system seems to work well. The main problem of local production of hand pumps is the lack of proper raw materials.

Mr. Alemayehu Bekele, TUT
Mr. Ashenafi Kibret, TUT
Mr. Ayele, Haile Mariam, TUT
Mr. Dejene Bekele, TUT
Mr. Gezahegne Wolde, TUT
Mr. Laike Selassie Abebe, TUT, reporter

THE ROLE OF WELLS IN RURAL WATER SUPPLY IN ETHIOPIA

1. Introduction

Safe and adequate water is one of the essentials of life. Providing people with safe and adequate water requires the utilization of the available water sources in which ground water plays the major role.

Ground water exploitation for water supply in Ethiopia is a recent endeavour although traditional wells have been in use for many years. Knowledge of the use of hand pumps is still not adequate. Traditional wells have pulleys, rope and bucket systems for lifting water. However, they are exposed to all types of pollution. The cost of surface water treatment is relatively high and uneconomical for rural water supply purposes.

2. What Criteria to Use in Planning Wells as Rural Water Supply Source?

It was agreed that the criteria depend on the type of well structure used, the population served, settlement patterns of rural villages, accessibility, as well as the available financial and material resources.

According to the order of their importance and our practical observations, the following planning criteria were found.

2.1 Determination of Finances, Manpower, Equipment and Material Resources.

During planning attempts have to be made to allocate the available resources economically and properly. According to the available resources the utilization capacity and distribution has to be investigated.

2.2 Demographic Study

The number of population to be served and the settlement condition of the area in question has to be studied.

2.3 Priority According to Need

Priority list has to be established and considered bearing in mind the existing situation of water supply and other factors.

2.4 Hydrogeological Study

Hydrogeological study has to be carried out thoroughly for proper location of wells.

2.5 Level of Community Participation

Community plays a great role starting from the planning stage up to the implementation, operation and maintenance of the wells. Community's contribution can be in terms of cash or labour and this has to be studied prior to implementation of the project.

2.6 Design of the Well and Well Structure

Design of the well and well structures depends highly on soil conditions. During design the well structure has to be dimensioned properly and economically.

2.7 Construction Schedule

For proper utilization of the allocated resources, available manpower and equipment and completion of the activities, construction schedule has to be prepared and properly followed.

2.8 Implementation

Implementation of the project should be carried out according to the construction schedule in order to complete the project in time and so to help to use the manpower and equipment for other projects.

2.9 Operation and Maintenance

After the construction of the well the major aspect is to keep the scheme in operation. This has to be planned in advance together with the planning of the well construction.

3. Most Severe Constraints and Aspects to be Taken into Account

In any project execution, different constraints can be encountered in one way or another. Also in groundwater development there are constraints which hinder the implementation of the project such as funding limitations, lack of manpower, insufficient health education, operation and maintenance problem, logistics etc. With regard to well development in rural areas of Ethiopia, the major prevailing severe constraints are funding limitations, operation and maintenance as well as insufficiency of trained personnel.

3.1 Funding Limitations

The main funding sources for development of rural water supply projects are international aid, government and community sources. To facilitate more rural water supply development projects the amount of funds allocated from these sources is, at the moment, not sufficient. The funds from international aid are used for purchasing equipment and material from foreign and local markets. In most cases the funds do not arrive on time from the organizations. There is also improper allocation of funds for different project components such as project investment, training personnel, operation and maintenance etc. There is also lack of efficient financial management and control.

3.2 Operation and Maintenance

The main objective of ground water development programme is supporting adequate and reasonably clean potable water. To fulfill this objective the day-to-day operation of each well with regard to well performance, preventive maintenance, such as greasing and proper maintenance after failure is vital. However, this part of the work is given little attention because of inadequate management organization of maintenance. This problem is enhanced by the insufficiency of spare parts, maintenance equipment, transport facilities and skilled manpower.

3.3 Training

Project implementation will be hindered by the insufficiency of manpower. Lack of high level professionals, sub-professionals and skilled manpower is one of the major constraints of ground water development. Insufficiently organized local training programme and incentive for the trained manpower are also major hindrances.

4. Suggestions to Overcome the Constraints

4.1 Funding Limitations

Project implementation is basically dependent on the initial preparation of the project and the proper project preparation will give adequate information for policy makers of the government and the international donors. The funding limitations of the project, expected problems in operation and maintenance of the supply system as well as the inadequacy of the project and the operation staff should be pointed out in the planning stage of the project. A planned project should be presented by a project report or document which will have the following information.

- objectives of the project
- type of scheme
- cost of the project and breakdown of the cost into local and foreign components.
- financial allocation for the various activities of the project
- required manpower

4.2 Maintenance

The expected operation and maintenance problem can be partially solved during the initial stage of the project. Organizing efficient operation and maintenance system, proper allocation of skilled manpower and identification of community role should be pointed out in the planning stage.

In Ethiopia, rural water development programme is designed to be coordinated and implemented by Urban Water and Sewerage Authority. At present, the authority is planning to open regional offices at seven regions of the country. However, to make the plan realistic, adequate skilled personnel, offices and office facilities are needed. It is also vital to strengthen the planned regional offices by workshop and store facilities as well as to establish a regional water laboratory for quality control.

4.3 Manpower

Even though ground water sources from shallow aquifers are utilized in more traditional ways, large scale ground water development programmes need professional and sub-professional personnel. To overcome the present manpower constraints, a new training institute is established at Arba Mincha (Southern Region). It is indispensable to strengthen the institute in material, teaching staff and funding to run the training programme efficiently. At present the institute is training sub-professionals of the National Water Resources Commission. The training of the high level professionals, mainly hydrogeologists and water engineers depends on overseas training. This can be arranged either through a certain project, by scholarships sponsored by international organizations or by scholarships sponsored by developed countries on the basis of bilateral agreements.

Apart from a training programme, exchange of experiences through organized seminars and workshops will upgrade the technical knowhow of the staff and solve the major technical problems which are encountered during project implementation.

It is also important to establish a kind of incentive for the employees in terms of salary increment and promotion.

5. Suggestions for Well Structures

One of the aspects of engineering design is dimensioning of structures by appropriate technical and economical methods. Accordingly the following suggestions on appropriate well structures are given.

5.1 Shallow Wells

Hand-dug well (small diameter $\simeq$ 1 m)

- precast concrete rings, masonry lining
- hand pumps, rope and bucket, windmill.

Hand-dug well (large diameter > 2 m)

- masonry lining
- hand pumps
- concrete cover slab

5.2 Auger Drilled Well (machine)

- casting
- motor driven pump
- concrete sealing
- screen
- gravel packing

5.3 Borehole (deep drilled well)

- screen
- casing
- submersible pump
- concrete sealing
- gravel packing

6. Suggested Organization for Development Co-Operation Projects in Rural Water Supply

Earlier the level of ground water utilization in Ethiopia was not adequate and modern exploitation methods were not well known. Nowadays the need for ground water development is highly increasing because of its quality, economic and other technical aspects. Especially the shallow aquifer wells are becoming very essential due to their ease of construction, simple installation of lifting devices, sufficiency for small communities and other related factors.

The present activities of rural water supply well development is mainly divided into shallow and deep aquifer projects.

Shallow aquifer projects

- shallow well construction
- spring development
- infiltration galleries.

These schemes are mainly provided for small communities.

Deep aquifer projects include construction of boreholes (deep wells) which serve mostly large communities. At present the above-mentioned activities are carried on regional basis in the country in cooperation with international organizations. The main inputs of these donors can include

- purchase of construction materials, equipment, machinery, technical assistance etc.
- study of ground water resources inventory

The government's inputs include

- human resources on various levels of skill
- recurrent budget allocation for the employees
- subsidizing the cost for maintenance, operation and fuel.

The inputs from the community can be in the form of contributing money, organizing labour, collecting local construction material like sand, gravel etc. After the completion of the project construction the community must also participate in the operation and maintenance of the scheme.

Since most of the rural water supply development projects are assisted by international organizations which come to the country at the same or different times, coordination between these organizations is highly essential. The coordination of local organizations is important, too. This has to be properly organized by the Water Supply and Sewerage Authority which is in charge of the different regional rural water supply projects.

DISCUSSION

Mr. Luonsi wanted to know the share of water supply compared to other sectors in the national economy in Ethiopia. *Mr. Ashenafi* replied that agriculture has got top priority at the moment but, however, the resources allocated to the water sector have increased with 20...25% during the last few years. The *Chairman* said that in most developing countries there are very often much more important sectors but the goal could be keeping the share of water supply and sanitation reasonable.

Prof. Viitasaari reminded of the thesis by Mr. Berhane, a previous course participant who discussed e.g. the level of technology. He suggested that in large areas in rural Ethiopia hand-pumps represent, at the moment, too high technology. In the seminars of the previous M.Sc.-course it was also suggested that all water projects should be integrated with agricultural development. How should the water projects be linked with agricultural development?

The *Speaker* replied that the group did not consider the improved open well (Fig 1) as a real alternative but instead of handpumps, the sanitary rope and bucket method (windlass with a cover Fig 2) could be used. The *Chairman* reminded that the suggestion of Mr. Berhane was meant only for those areas where it is not possible to arrange the operation and maintenance of hand-pumps. However, this structure would be an improvement compared to the use of traditional totally covered sources.

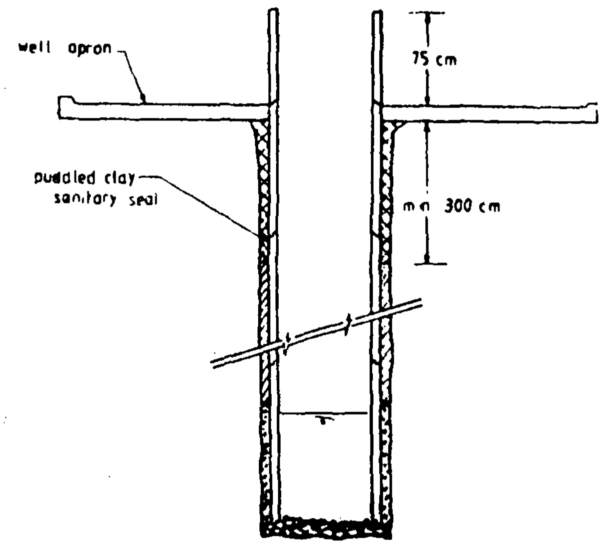

Fig 1. An improved open well to be used by rope and buckets (Berhane 1984).

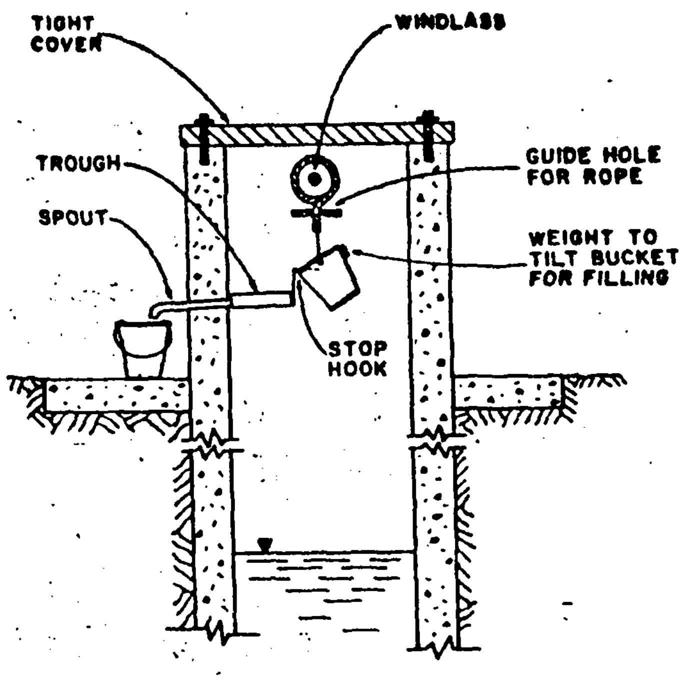

Fig 2. "Sanitary" rope and bucket with windlass.

Mr. Ashenafi mentioned that in some areas there is an acting link between the Ministry of Agriculture and the Water Commission. *Prof. Viitasaari* suggested that the idea of integrating water supply with agricultural development, is connected with population growth based on improved water supply and sanitation. The *Speaker* said that there should be an effective coordination between different sectors of development. *Mr. Teizazu* reminded that the major part of agricultural production is based on the rainy season. Under the Ministry of Agriculture there is the Department of Irrigation.

Mr. Luonsi wondered about the level of water hygiene at the users' homes. If the water handling is not hygienic then what is the use of protecting the source? The *Speaker* replied that we have to start somewhere. *Mr. Nokso-Koivisto* reminded that the main two aspects are quantity and quality as well as their relationship.

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Mr. Lawrence Musyoka, TUT
Mr. Richard Ngare, TUT
Mr. Samuel Ngari, TUT
Mr. Ezekiel Nyangeri, TUT, reporter
Mr. James Thuku, TUT

THE ROLE OF WELLS IN RURAL WATER SUPPLY IN KENYA

1. Introduction

The Kenyan group considered these the most severe constraints in rural water supply: funding limitations, operation and maintenance as well as logistics (materials, spare parts, transport and fuel).

2. Funding Limitations

2.1 Source of Resources - Internally

Possibility of increasing government budget for the Ministry of Water Development should be looked at carefully. To avoid duplication of work, water implementing agencies of central government should be coordinated very well.

Community participation in terms of labour and money should be considered seriously. This sort of participation could substantially cut down the cost of construction of a water supply system. Community participation could also be used to offer such things as transportation.

Local authorities are also involved in construction of water supply. They should increase finances for water supply projects and they should cooperate with the relevant government ministry to avoid duplication of projects. This will result in better utilization of limited resources.

There are also local non-governmental organizations which aid the water supply sector, for example

- Freedom from Hunger Organization of Kenya
- "Maendeleo ya Wanawake" of Kenya
- Others e.g. church organizations.

2.2 Source of Resources - Externally

The richer nations should assist the poorer nations especially in development. This grant should be in the form of materials and money.

Terms of loan and repayment should be favourable. Preferably the form of loan should be in terms of machinery and money to purchase locally available materials.

International organizations such as UNICEF and FAO should be approached.

2.3 Local Materials

Disencouragement of importation of locally available materials is essential. Sometimes there have been complaints that locally produced materials are of lower quality. The Kenya Bureau of Standards should control the quality of the locally manufactured materials. Research to develop appropriate technology should be encouraged. An example is the bamboo reinforced tank developed at Karen, Nairobi.

3. Operation and Maintenance

3.1 Improvement of Performance

Organization:

The departmental organization should be such that qualified personnel are to fill the vacancies. Records and operational manuals for the water supply systems should be kept and the data obtained should be analysed. This would help to know the operation of the system during its life.

Training needs should be identified within the Ministry. Appropriate training should be given in terms of arranging seminars, long and short courses as well as special training to attain higher grades. Training places should be identified such as the Ministry's Training School, The Kenyan Polytechnic and the University of Nairobi. If the training needs are not satisfied locally, overseas arrangement should be made.

To increase the working incentive of workers in various positions, promotions should come in time and to the deserving people. Scheme of service should be followed according to the real need. Rotation of the personnel to different water supply projects should also be encouraged.

3.2 Community Participation

Operators should be selected early enough especially during construction stage - from the community.

The community should be honest and report all the stolen materials, for example, diesel, cement etc. Community has to inform of any vandalism of water supply facilities to the water administration. The community should be involved in simple maintenance work, for example, in oiling hand pump parts, tightening nuts and repairing pipe leaks.

For better utilization of a well and associated facilities the community should be educated by the extension on benefits to be achieved, if people use water from the well.

For mobilization of the community the local leaders should be involved. In cases where one would require a community built well, the only way to succeed is by help of local leaders.

3.3 Operation and Maintenance of Equipment

Machinery used for extraction of ground water should have standardized parts. Only a few selected types of hand pumps should be used.

The hand pumps should be simple enough to be operated and maintained by the community. The community should assign itself such simple preventive maintenance tasks like greasing all movable parts of a hand pump and tightening any loose nuts.

Any fast wearing parts should be made available to the community. The community should be encouraged to always have some stock of much used parts of a hand pump. To ease the problem, of spare parts, decentralization of stores to district level should be done. This will mean that the community will be able to get its spares from district head-quarters.

4. Logistics

It has also been found necessary to suggest improvement of the following water supply supporting infra-structure like trunk roads and other access roads. Improvement of means of transportation should also be studied. Vehicles, bicycles and motorbikes should be made available to the district head.

Another matter that would need to be considered is proper storage of construction materials. It is a well known fact that a lot of construction material is spoilt due to bad storage.

DISCUSSION

Mr. Musyoka added that in the past the development of water sector did not have the part of community involvement . However, later the initiative from communities has been taken to divisional development communities and therefrom to district and national level. In this way the people feel that the project in any development sector belongs to them. In districts there is coordination between the Ministry of Health, Water Development and Agriculture which have got "assault" development programmes.

So far shallow wells have not been popular in the Government. However, during the last few years we have had ground water projects aided by the Finnish, Dutch and Swedish governments. As time goes by there will be further investigations and development of ground water.

Mr. Odira said that people in some areas are used to having piped water and therefore there is resistance of water supply arranged by ground water wells among the water users. People easily think that the well is a temporary solution and they prefer to have taps. When people become more aware of the potential of ground water the attitudes will change. People are used to thinking that they can participate in construction of piped water supply but not in construction of shallow wells.

The *Chairman* pointed out that in some areas Kenyan communities have already contributed money for operation and maintenance of shallow wells and ground water utilization has thus started to be accepted.

Mr. Alemayehu wondered how the pattern of settlements affect water supply in Kenya. The speaker replied that it is difficult to arrange permanent water supply for nomade people who move from one place to another. During the dry season the people have to move from their dwelling places because there is no grass for the cattle although they can have a borehole. Schools and other facilities share this problem.

Mr. Allan Mcharo, TUT
Mr. Joseph Mosha, TUT
Mr. Colman Ngainayo, TUT
Mr. Mfungo Rukiko, reporter

ROLE OF WELLS IN RURAL WATER SUPPLY IN TANZANIA

1. Introduction

Since independence in 1961, the Government of Tanzania has vigorously implemented programmes meant to provide social services like water supply, education and health for people in the rural areas where more than 80 percent of the people live. As a follow-up to this policy in the rural water supply sector, it set a target of providing all people in the rural areas with clean and safe water by the year 1991 within 400 m of their homesteads.

The sheer magnitude of this task in combination with financial limitations necessitates the increase of emphasis on the utilization of ground water through shallow wells and deep wells. Utilization of ground water which in most cases does not need expensive treatment, offers an economical alternative to surface water which almost always is bacteriologically unsafe and therefore requires elaborate treatment processes.

2. Constraints and Their Remedies

The major constraints assessed by the group were logistics, operation and maintenance as well as manpower.

2.1 Logistics

These are mainly materials needed for construction of wells and piped water supply schemes like pipes, pipe fittings, reinforcement bars, cement, aggregates and timber. They are mostly not adequately available. The inadequate raw materials for the locally manufactured pipes and the low capacity of rolling mill is due to foreign exchange constraints. Cement which is presently available in quantity at the manufacturing industries is hampered by transportation limitations to the regions and to construction sites. The crushers for aggregates and sawing mills for timber suffer from the problem of inadequate fuel supply.

There are not enough spare parts for pumps, vehicles, plant and craft because of foreign exchange limitations.

The transport facilities are inadequate due to limitations in foreign exchange. Besides the existing facilities are not properly organized. Also the roads and railway lines are in poor condition.

Fuel and lubricants are insufficient mainly because of foreign exchange problems. The transportation of the materials which are not readily available is hampered by poor transport facilities from the refinery to the regions. Office equipment and machines are not always available due to small purchasing power.

2.2 Operation and Maintenance

Manpower potential of the professionals and semi-skilled personnel is insufficient. Insufficiencies include spare parts, transport, fuel and lubricants. Funds allocated are mostly inadequate.

Most of the constraints have fund limitations, as the main bottleneck. The following are suggested solutions to the problem:

- Import support facility from donors
- Long-term measures are needed in terms of increased agricultural production and soft loans for better industrial infrastructure.
- Continued efforts in identifying potential natural resources like petroleum which can be a foreign exchange earner.
- Economical alternatives should be preferred whenever possible like use of gravity schemes, hand pumps, hydraulic rams and wind mills.

Local Funds

- Higher budget ceiling for water supply sector
- Timely release of approved funds from the treasury
- All funds allocated for the financial year should be released
- Proper management of funds

Spare Parts

- Ensure enough stock of spare parts particularly fast moving items
- Standardization of pumps and parts
- Quality control of locally made spares.

Organization

- To decentralize the central stores to zonal stores which would cater for several regions.

2.3 Manpower

- Incentives to professional and semi-skilled staff to reduce brain-drain. They should be provided with better working conditions.
- Seminars for engineers to exchange ideas on operation and maintenance problems
- Proper allocation of the existing manpower
- For the semi-skilled manpower, the intake to the Water Resources Institute should be increased. Also the regional on-the-job training programmes should be expanded.
- In-service training programmes to be enhanced
- Village level training for maintenance of hand pumps, wells, pipelines and gravity schemes.

3. Appropriate Well Type and Structure

3.1 Shallow Aquifers (4-15 m)

- Ring wells (hand dug) (≤ 7 m)
  Structures include concrete slab, (disinfection is necessary), extended apron.
- Auger wells (hand drilled) (up to 15 m) and for aquifers with high transmissivity pvc slotted screens and casing necessary
- Lifting device: hand pump
- Villagers to provide labour during construction and to carry out maintenance.

3.2 Medium Depth Aquifers (15-30 m)

- Machine chilled, pvc slotted screens and casing, gravel pack and well cover including extended apron.
- Hand pump/wind mill.

3.3 Deep Aquifer (>30 m)

- Deep well/borehole
- Machine drilled
- Screen and gravel packed casing
- Diesel/electric pump/hand/wind pump according to appropriateness
- Piped supply.

Community participation is necessary for the sense of ownership, prevention of vandalism and for the reporting of major breakdowns to water office. It is important to train some of the villagers to act as pump attendants and well caretakers.

It is of utmost importance that standardization of handpumps is taken seriously.

4. Development Co-Operation

4.1 From Donors

- Professional manpower
- Materials and equipment
- Capital

4.2 Input from Recipient Country

- Professional manpower
- Semi-skilled and unskilled labour
- Some of the construction materials e.g. cement, steel reinforcement bars and pipes.

DISCUSSION

Mr. Luonsi asked about the level of success of Tanzanian community participation at the moment. The *Speaker's* view was that the present situation is already good even though it varies from place to another. The response of communities to shallow well programmes have been encouraging in most cases. *Mr. Luonsi* wondered whether there is still something to be done to improve the level of involvement. The *Speaker* admitted that after a few days the number of people participating in the work can decrease. The *Chairman* wondered if the reason for this could be that the people do not see any need for wells. The *Speaker* noted that it is a question of priority and particularly money. Some people do not appreciate water as much as other services.

Mr. Teizazu wanted to know the reason for successful community participation in well construction in cases where surface water resources are available. The *Speaker* acknowledged that in some cases it can be difficult to get the community to participate in well construction.

Mr. Ngainayo added that the level of community participation and possibilities vary a lot depending on the conditions. In highland areas of northern Tanzania, shallow wells are not necessarily the solution but in lowland areas with shallow aquifers, shallow wells are often the only economical alternatives. The *Chairman* pointed out that only 50 % of the rural areas in Tanzania can be supplied with shallow wells.

Mr. Seppälä referred to the presentation concerning special arrangements in case of breakdowns of hand pumps. The *Speaker* explained that normally a dug well should be equipped with a manhole via which people can use their rope and bucket system if the pump has broken.

Mr. Nyangeri wondered about the effect on community participation if the well is sited incorrectly and proper aquifer is not reached. *Mr. Mashauri* replied that if the community is involved also in the planning stage, in well siting the responsibility will be on the decision-maker's , the village's side or at least it will be shared. *Dr. Swantz* said that this situation has occured when the community has suggested one place and the expert another. *Prof. Viitasaari* continued that according to his experience the villagers did not necessarily reveal their best water source. *Dr Swantz* referred to a case where the traditional water source got dry after the rings were installed. People have their discouraging experiences and they cannot afford to lose their own source. *Mr. Ngainayo* admitted that people have experienced a lot disencouragement. Therefore, they have to be informed from the very beginning about those factors which concern them and their involvment.

Mr. Katko reminded that people have limited possibilities for well siting. They might be accustomed to utilizing perched water which is quite often not enough for a well. On the other hand it is quite impossible for the people to locate medium or deep aquifers which can be utilized by boreholes.

Mr. Heikki Akkanen, TUT
Mr. Laurent Sechu, TUT
Mr. Tilahun Teizazu, TUT
Mr. Panu Tolla, TUT
Mr. Robert Zimba, TUT, reporter

THE ROLE OF WELLS IN RURAL WATER SUPPLY IN ZAMBIA

1. Introduction

Zambia is a large country (about $7 \times 10^5 km^2$) with a population of about 6 million. About 60 % of the population live in rural areas which are sparsely populated. Groundwater resources in Zambia are abundant in most areas either as shallow aquifers or deep aquifers.

Ground water has been used for a long time. Dug wells are still being greatly utilized in villages in rural areas. At the moment rural water supply projects are being constructed with the help of various international organizations. For example, Irish development assistance is funding and executing work in the northern province while Norwegian Agency for International Development (NORAD) is involved in work in the western province of the country.

2. Constraints

There are many constraints in rural water supply projects. The authors of this paper feel that the three most severe constraints in rural water supply projects in Zambia are: funding limitations, lack of professionally trained people and inadequate cost recovery.

2.1 Funding limitations

Plenty of resources, either financial or human, are needed for the development of water supply projects in rural areas. In order to overcome funding limitations, fund raising committees should be set up at local and national levels. These committees will be responsible for setting up programmes for scouting of funds from local communities. National charitable organizations should be asked to help. The funds can be either loans, aid or contributions and in the form of money, material or human resources.

Other local, regional or governmental institutions should be set up to ensure effective use of the funds, proper management and security of the funds. These institutions will keep records showing the funds available and how they are being utilized. They also ensure security of funds and proper storage of materials being used in water projects to avoid destruction due to the climate.

2.2 Professional Manpower

Zambia has, at the moment, still very few professionally trained personnel which are essential in planning, development and construction of rural water supply projects. This constraint could be overcome by executing extensive training programmes for professionals. The professional training should cover technical, economic, social and health aspects related to rural water supply projects of the country.

People to be trained should have basic knowledge in their fields and they should be willing to work for the projects after completing their training. At first, foreign and local specialists should be involved in conducting the training. However, when these trained persons have got adequate experience in the field, they should also be utilized in training of other professionals.

According to various needs and objectives, training may be conducted in local institutions or in foreign countries. If there is any choice, it would be advantageous to conduct training in foreign countries where problems similar to those in Zambia have been successfully solved. Money for training should be provided by local or international sponsors but it should be emphasized that the projects should draw up programmes and finance continuous training (refresher courses etc.) for the trained personnel.

To ensure good results the trained personnel should be properly allocated and should be motivated by job satisfaction, salaries and also by promoting those who have got required experience. Feedback and evaluation should be conducted in order to adjust training programmes to suit the objectives.

It is very important to have cost recovery measures for the rural water supply projects so that operation and maintenance costs are gathered. This increases the effectiveness of a water supply project. It is true that most of the people in rural areas of Zambia are poor. This fact is just one of the reasons why simple and reasonably cheap alternatives should be adopted in these areas. In this way the little money that will be collected is enough for the running costs of the projects.

Local and regional authorities of the projects in rural areas should be responsible for collecting of rate payments. Rates should be fixed, they should cover operation and maintenance costs and they should also generate profit which will enable expansion of projects.

Proper records and receipts of the money collected should be kept and banking facilities should be utilized.

3. Well Structures

Ground water availability and the types of aquifers vary from place to place. The types of well structures to be adopted in an area will mostly depend on the type of aquifer and also on the level of development of the community (e.g. in the form of agriculture).

3.1 Areas of Shallow Aquifers

In these areas the types of wells to be used are improved dug wells, ring wells and auger wells. The lifting devices will be rope and bucket method in terms of improved dug wells and hand pumps for the case of auger wells and ring wells.

Construction methods to be adopted will depend on the type of formation but hand digging and hand drilling should be used whenever possible. Otherwise machine drilling should be done where formations are of such type that it is not possible to have hand digging and hand drilling methods.

To reduce construction costs, locally available materials should be used whenever possible. Locally available materials include cement and aggregates for concrete, masonry, bricks, gravel and concrete blocks. Precast concrete rings can also be manufactured locally although reinforcement steel has to be imported. Steel casings and steel screens can be used.

3.2 Areas of Deep Aquifers

In these areas boreholes should be used and method of well construction will be any kind of machine drilling method. Hand pumps, wind mills, electrical pumps, diesel pumps or solar energy should be utilized for lifting devices and the choice will depend on conditions in a particular area. The construction materials to be utilized in this case will include concrete, gravel and steel casings and screens.

Ownership of all well structures in rural water supply projects should be communal. Community participation should be encouraged in planning, construction as well as operation and maintenance of the projects. Operation and maintenance should be taken care of by selected and trained people from the community but heavy repair work should be conducted at district level.

It is important to standardize certain parts of the equipment to be used so that operation and maintenance work will be easier and cheaper. Also certain improvements should be done so that there are alternatives for obtaining water even if a pump breaks down.

4. Organization of Development Co-Operation Projects for Rural Water Supply Projects

Development cooperation projects for rural water supply projects should be organized in such a way that there will be contacts between various projects, government institutions, donor agencies, execution agencies and the community. This is important so that work in a particular region is done properly. Coordination between these organs will enable problems to be solved easily and also to develop better methods.

The govermental sectors like the relevant ministries should provide the relevant information related to water resources and they should be responsible for organizing the communities and educating them. These ministries should also provide the required manpower and financial resources. Water resources inventory should be carried out by the relevant government ministries.

Donor agencies should provide skilled and professional manpower, capital and also do a part of water resources inventory. They should also know the needs of the country. Government ministries should be consulted on the equipment to be used, types of structures to be adopted and also standardization needs of equipment.

DISCUSSION

The *Chairman* noted that so far we have got limited knowledge on ground water resources in Zambia.

Dr. Swantz asked whether there are more practically trained people in Zambia compared with other countries in the same region and whether it is easier to find people for maintenance purposes. The *Speaker* said that those people who have worked in the mining sector have gained skills for any type of maintenance work. However, the lack of professional manpower is a very severe constraint at the moment in the water sector. The *Chairman* said that the same holds for the whole civil engineering field because the mining sector attracts the professionals.

Mr. Luonsi wanted to know the level of cooperation between the agricultural, water and health authorities. The *Speaker* said that he feels there is need for real cooperation between different ministries but also donors who all have to work together. The *Chairman* noted that at least the agricultural and water sectors belong to the same ministry.

The speaker referred to an article about Zambian resistance towards handpumps (Fig 1). An Irish donored project is using partly open wells equipped with windlass and bucket because they feel it is not possible to arrange a reliable maintenance system for hand pumps. If the pump is not working, people go to their traditional water sources.

Mr. Nokso-Koivisto said that after using safe water from a protected well people will have health risks e.g. diarrhoea if they start using their traditional sources.

Mr. Thuku asked what kind of effects the pattern and distribution of population have on water supply and community participation. The *Speaker* clarified that in Zambia there are communities but not as big as in other countries. Communities are quite large e.g. you may find villages under one hundred persons at a distance of a few kilometers. In such case piped water supply systems are far too costly. As a whole, ground water utilization should be encouraged in rural water supply in Zambia.

Handpump locally made in Zambia

Typical Zambian dug-well

Zambian handpump resistance prompts Irish dug-well programme

One answer to the problem of selecting the right handpump for water supply in rural areas in developing countries is to do without them altogether, and this is what an Irish development assistance team will endeavour to do in its Kasama District Water Supply programme in Northern Zambia.

Observations in the area around the northern provincial capital indicated widespread disillusionment with handpump installations due to the high incidence of breakdown. The team also encountered many experienced well diggers currently unemployed because of a shortage of funds.

This means that An Foras Forbartha — the National Institute for Physical Planning and Construction Research — will channel its initial efforts to well-digging schemes, with local manufacture of the materials required.

The pollution factor has always been the compelling indictment of open wells — a pollution passed into the well by the use of individual buckets which are often dirty. An Foras hopes to limit this transmission of potential disease by having the windlass operate a single bucket.

Even here the bucket is usually dirtied by the handling involved in transmitting its water to household vessels, but it is hoped that intensive public health programmes will mitigate such problems.

This will involve visits by medical experts from Ireland complemented by regular in-village public health courses from nurses or medical visitors from area hospitals or clinics.

It is accepted by the Irish team that no amount of public health education can make windlass-and-bucket as safe as a handpump, and the original idea was to equip all wells with pumps.

Such was the resistance among village populations — often accustomed to seeing broken pumps unrepaired for years — that the windlass strategy evolved. It will mean that pumps will be provided where villagers can be persuaded to give them another chance, but in other communities — expected to be in the majority — the windlass system will be provided.

An Foras acknowledges that for certain communities hydrogeological conditions will not permit the sinking of hand-dug wells and that a borehole will be the only alternative, while in other larger villages or small towns piped water to standpipes will be required.

The Irish specialists stress that they have embarked themselves on a learning process as well as the manpower training programme which will be an integral part of the supply project. They have spent a great deal of time in the first year feasibility study talking to Zambian officials from the Department of Water Affairs, local village leaders and well and pump users, and expatriate technicians from international agencies and bilateral water supply programmes.

In Kasama, the An Foras representatives will have the benefit of working beside an existing project in which Irish specialists are assisting the Zambian

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Fig 1. An example of a project using partly covered wells equipped with windlass/ and bucket.

Mr. Heikki Iihola
Oy Vesi-Hydro Ab Consulting Engineers

DEVELOPMENT OF WELL STRUCTURES AND GROUND WATER UTILIZATION IN DEVELOPED COUNTRIES

1. Aquifers as a Part of Water Treatment Process

Ground water compared with surface water is generally considered safer and in many ways better raw water for producing drinking water. In some cases an aquifer can complete or even replace a complicated chemical surface water purification process.

In practice, in every surface water treatment process there is a filtration unit as an essential part of the treatment process. The filtration unit, as we know, is mostly an artificial sandpack, layers of sand of different grain sizes. In fact, we could call it 'a micro-aquifer'. Although the detention time of water in the filter is very short, say some tens of minutes, its effect on the purification result is important from both the mechanical filtration and the biological point of view.

If the quality of surface water is really problematic or the standards or the aims are on high level the treatment process is often completed with a slow sand filtration - a 'mini-aquifer'. In slow sand filtration the detention time is longer, say 1-3 hours, than in ordinary filtration, and biological purification in the filter gets more importance (Fig 1).

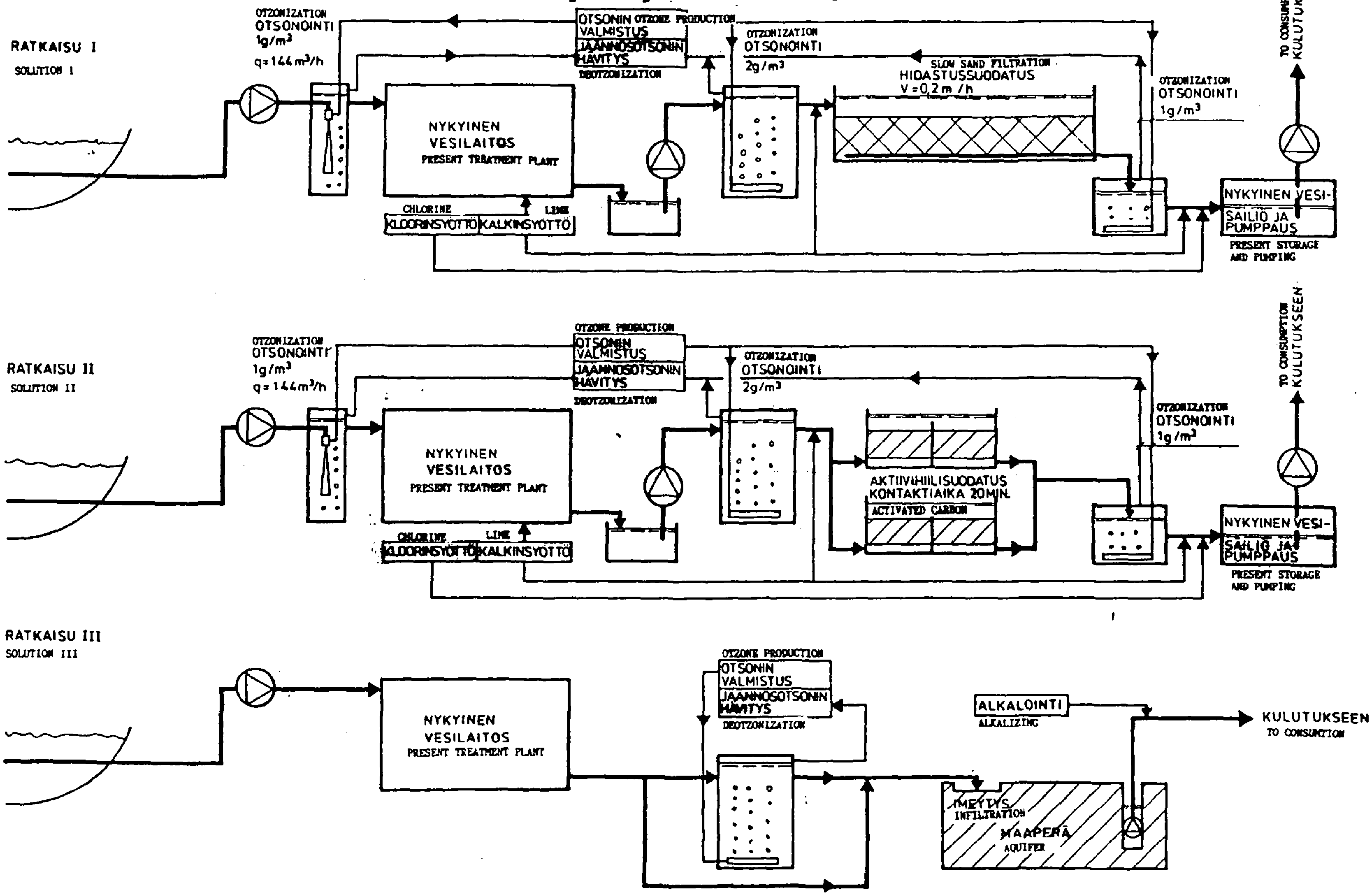
So the trend is: the more water quality problems appear or the higher the standards and the aims are the closer the filtration philosophy becomes to natural processes in an aquifer.

In developed countries shallow aquifers are used in many places as a part of water treatment process. As an argument for the use of aquifers its effect of improving especially odour and taste has been emphasized. In addition, aquifers will serve as water reservoirs in case serious pollution occurs in river water (Fig 2).

Thus the use of aquifers has become an aspiration as a source of drinking water and also as a part of surface water treatment process. In many cases the cheapest way to build a water treatment plant is to find an aquifer.

KUVA 1. VESILAITOKSEN TEHOSTAMISVAIHTOEHDOT

Fig.1. Alternatives for improving water treatment



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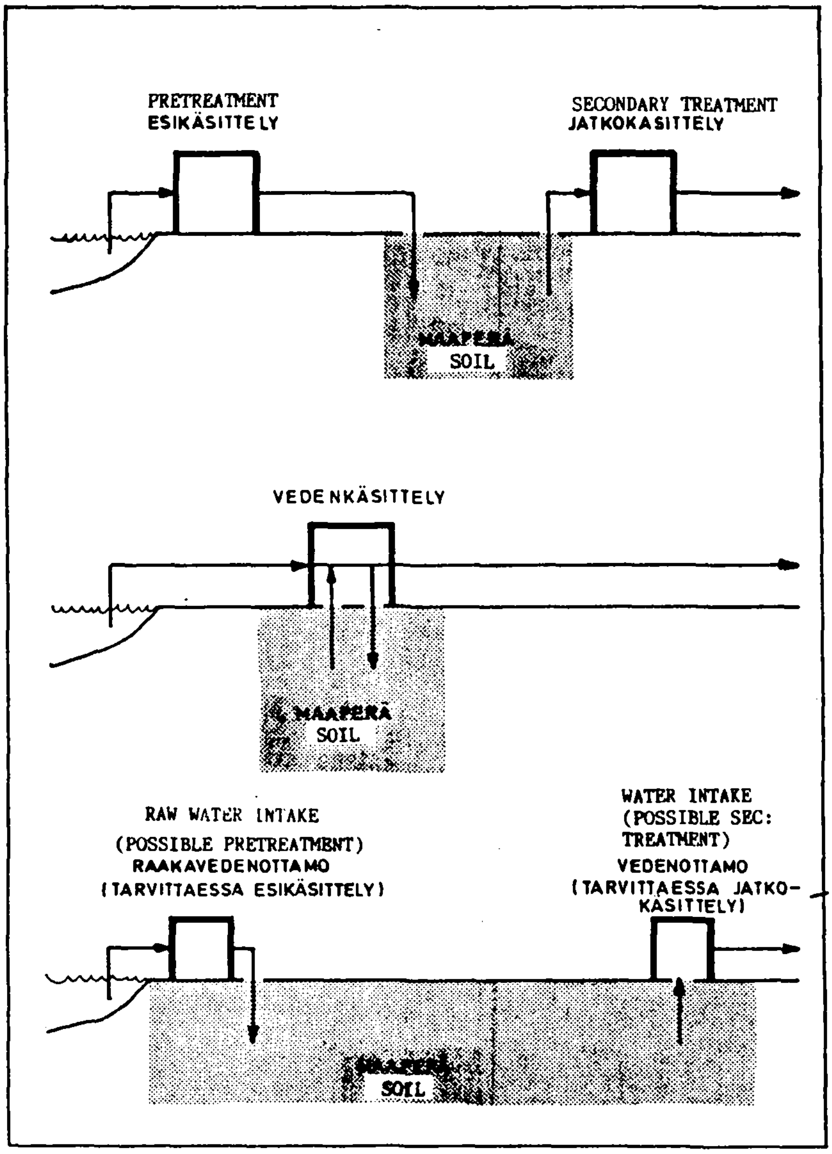


Fig. 2. Possibilities for the use of aquifers in water treatment processes

2. The Yield of an Aquifer and the Utilization Possibilities

In the workshop of 28.11.1984 most of the reporters concentrated on identification of aquifers by means of geology, mapping, different types of sounding, ground and ground water explorations, etc. When an aquifer has been identified it is possible to get ground water by drilling or digging a well. This kind of straight action is usually adequate in rural areas.

However, if the aim is to base the water supply of a town or a city on ground water it is necessary to know more of the hydraulic properties of the aquifers The geological knowledge is only a good beginning. The answers you have to know are as follows:

- What is the total yield of the entire aquifer?
- By what means is it possible to utilize it, from where and how much?
- Is it possible to use the storage capacity over a dry season, and for how long?
- What are the possibilities to recharge the aquifer by infiltrating lake or river waters or cooling waters?
- How about effluent seepage?
- Is it possible to use the aquifer as a part of surface water treatment process?

Before you can answer the questions you have to know the hydraulic parameters of the aquifer. You can get the best knowledge from hydraulic parameters by test pumping. During this operation the properties are reflected in drawdown versus yield, time and distance. You may have to estimate or sometimes 'gestimate' some properties and boundaries. After determining the hydraulic properties it is possible to calculate and simulate the changes of the ground water level beforehand. Qualification for this kind of work is that you are familiar both with the theory of aquifer tests and advanced ground water hydraulics.

The development of ground water resources in a large scale without adequate pumping test data is a speculative operation which may have unforeseen consequences.

3. Historical Outlook to Ground Water Utilization

The first municipal ground water plant in Finland was constructed in 1896 near the city of Turku. The design work was assisted by a German company.

As for well structures Figure 3 shows an example of a concrete ring well from 1910. In Figure 4 we have a typical drawing of a tubewell equipped with a screen and a hand pump.

Since the beginning of the century the well structures have not changed too much except energy and pump. The development of submerzible pumps made it possible to utilize deeper tubewells (Fig 5). The typical yields of tubewells in Finland are a few thousand m^3/d the biggest yield is about 15 000 m^3/d.

Finally I would like to conclude that ground water and surface water resources can be utilized together. We should always check are we able to use aquifers for natural treatment methods. Surface water resources were regarded as the most important sources for water supply in Finland until 1950's but thereafter the interest for ground water utilization has grown so that at the moment about 50% of our waterworks are utilizing ground water.

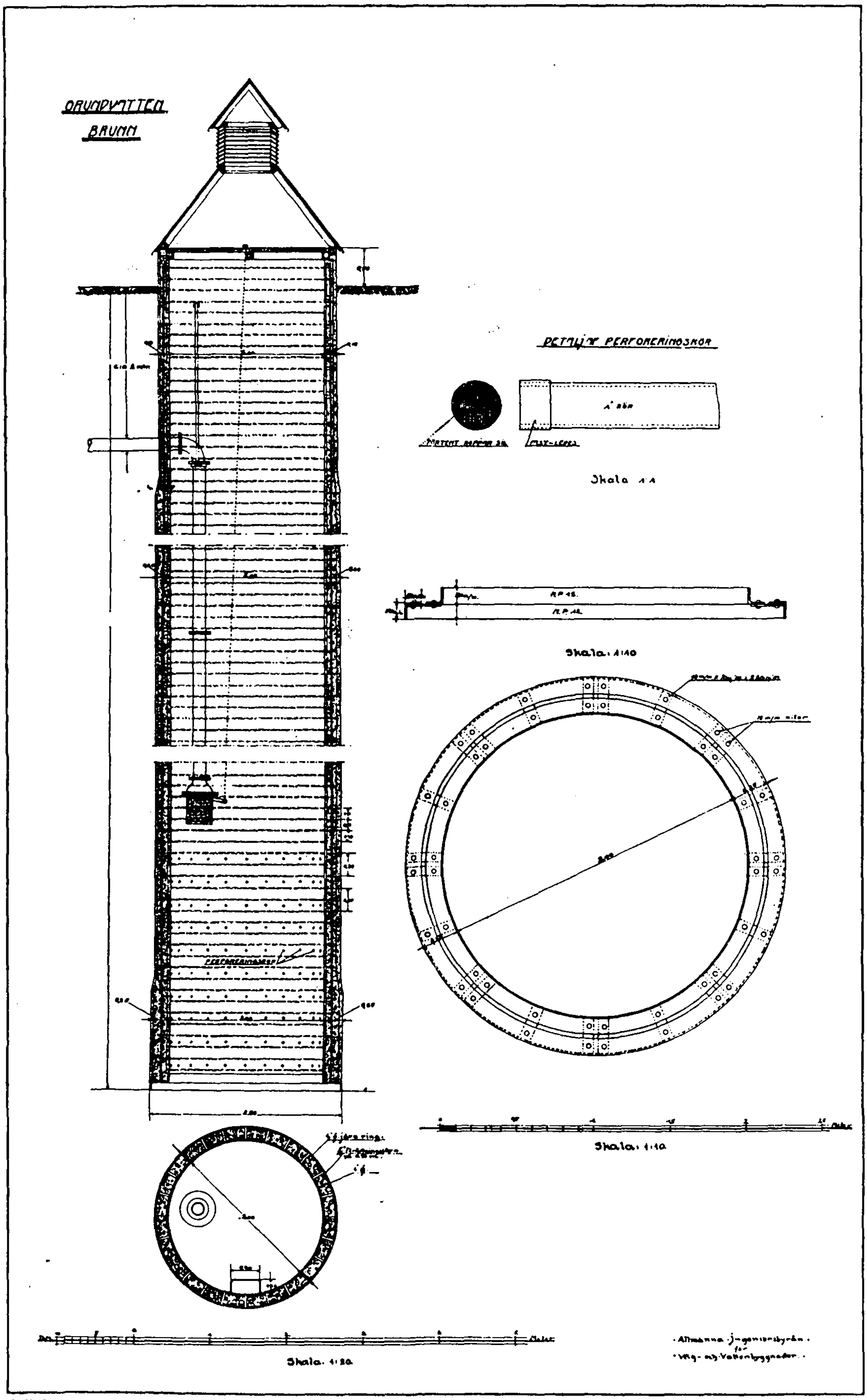
DISCUSSION

Mr. Laike asked how aquifers could be utilized for natural treatment in African conditions. The speaker said that especially aquifers in river valleys could be used for this purpose. *Dr. Rönkä* noted that with these aquifers we normally treat surface waters which easily means a piped system instead of hand pumps.

The *Chairman* reminded that the interest for ground water utilization has grown in Europe because the surface waters have often become polluted. In surface waters there are a number of chemicals which are difficult to remove and almost daily we find some compounds that are carcinogenic or dangerous for health in other ways.

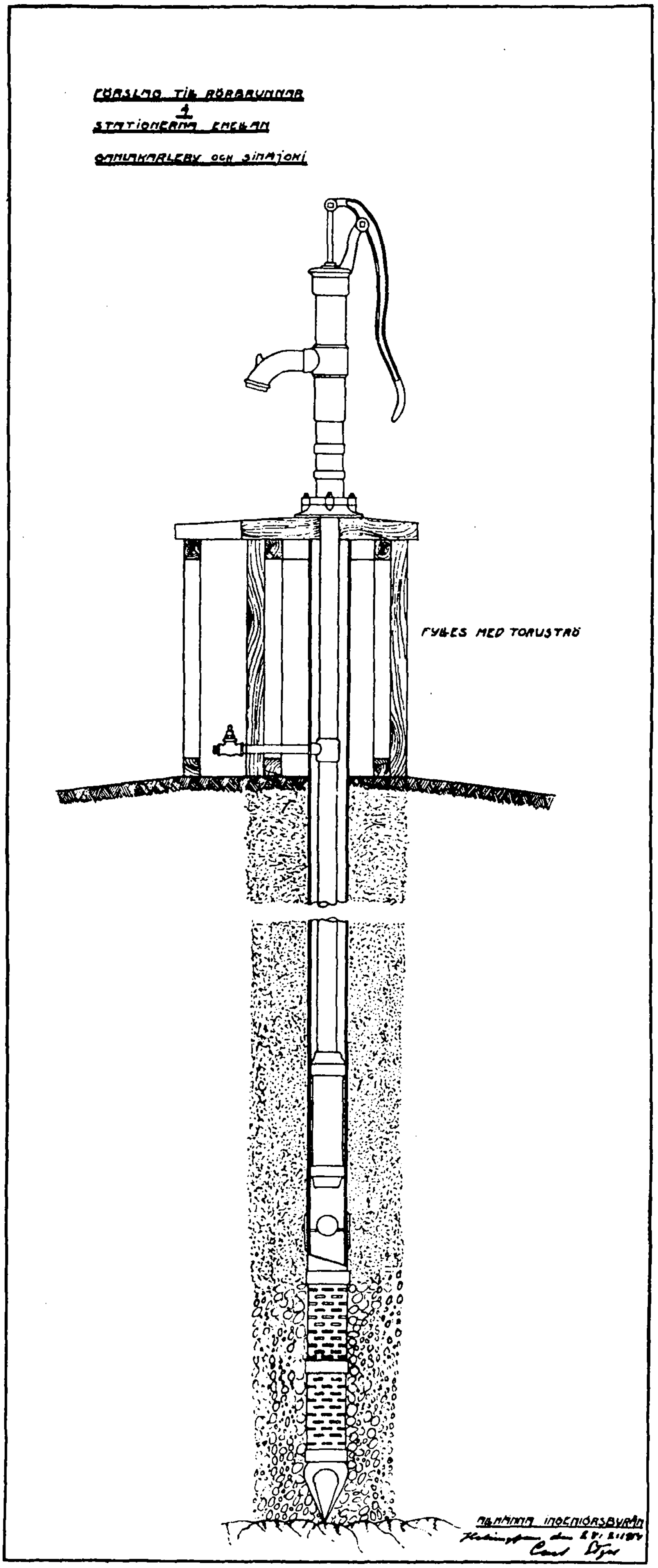
Mr. Luonsi wondered if there are any rough ideas about the costs of using an aquifer in water treatment. The *Speaker* replied that if we are going to utilize an aquifer of which we do not have any proper hydrogeological data the investigations may take 2...3 years.

Mr. Rantala pointed out that the hydrogeological conditions in Africa are quite different from those in Europe. Therefore, the possibilities to use artificial ground water with the technology used in Europe are rather low. However, there are good possibilities to utilize more river bed deposits by infiltrating the river water. The river waters very often contain much more silt than the waters in Europe and that is why the aquifers can get easily clogged. The *Reporter* agreed that in that case the use of an aquifer could be just one part of the treatment process.



Kuilukaivo
Rakennuspiirustus 1910-luvulta
Kuilukaivon vedenantoisuutta on pyritty lisäämään kaivon seinämiin tehtyjen siivikkoaukkojen avulla.

Fig. 3. A drawing of a sunk well from 1910´s. The yield have been increased by the slots on the lining.



Siiviläputkikaivo
Rakennepiirustus vuodelta 1914
Tällaisen siiviläputkikaivon antoisuus vaihtelee yleensä välillä 20—200 l/min.

Fig.4. A drawing of a tube-well from 1914. The yield is from 20 to 200 l/min.

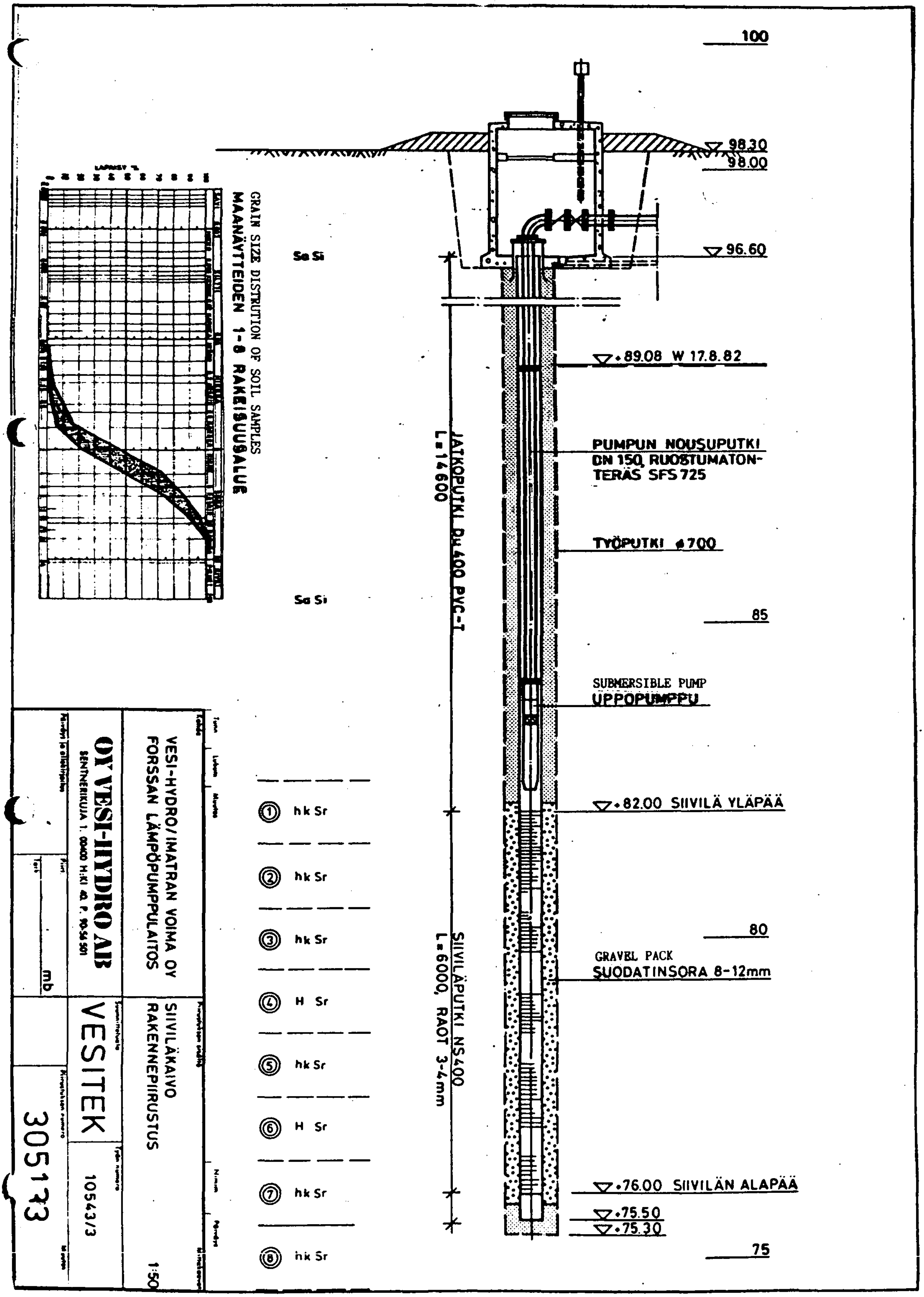


Fig 5. A tubewell used for gettin energy from ground
by a heath pump.

Dr. Marja- Liisa Swantz
Helsinki University, Institute of Development Studies

USER'S EXPECTATIONS FOR WELL SITING AND USE

1. Factors in Well Siting from the User's Point of View

Proper way of knowing user's expectations means that we ask the people for their wishes. We have to find out what official communication channels are used but we have to also know something about the inofficial channels. In water projects wells have perhaps been sited, not in relation to the actual needs of the community, but in the interest of some specific sector of the community. To know these interests you have to know something about the social structure of the community.

Social customs are another important factor related to water. There might exist important places for sacrificing or burial purposes. The people can have different beliefs about places and water. Sanctions connected to the use of these places are not necessarily told to outsiders. These factors cannot be known immediately but they require longer communication with the users.

Land ownership is one very important factor which varies quite a lot in different countries. For instance, the Maasai people who basically use the common water resources take out their "own part" from the river. It is not possible for everyone to draw water from a point belonging to the certain group of Maasai families. Water places have also got their own history to which it is very difficult for any outsider to penetrate.

2. Decisive Factors in User's Expectations

Good human contact with the users is extremely important because the results done in the technical field can be very decisive. Trustworthy continuing information is commonly lacking in most administration systems. If the community people do not know what a project is going to deal with, they have continuous fear against outside influence. Therefore, you have to build a continuing information system which is working in both directions.

Functionality of the project is based on availability of water which is quite an important factor. But if trustworthy information exists the functionality is a secondary factor. People have enough experiences of failed projects.

We easily forget that women are those who mainly draw, carry and use the water. There are seasonal and daily factors and variations in use of water which also affect construction of water resources. During construction women come under many constraints to join the community work and participation tasks whereas men commonly do not.

It is very important to know people's actual needs. We very easily talk on a theoretical level but do not know the actual situation. You cannot build a water supply system on assumed needs. In societies like that of Tanzania people are dependant on provisions given by administrators who think they know what people need. If you are known to listen to the people's needs you will get their cooperation.

I think we have to consider the political situation in societies and communities. For instance, in Tanzania the actual practice contradicts with the political goals and policy set out. If we had a more careful analysis of communities we could charge for water from some public amenities and wealthy users to cover the costs of those people who cannot afford it. For instance, you could introduce a tax on brewed beer which consumes a lot of water. In this way you could get the money from the men who often get their money from women's work. Schools could also be charged for water. But you need to know the differences between the users, which groups can afford to carry the costs.

To organize the work on village level you have to know how the people normally organize their activities. Village leaders could have reasons why some things are not wanted.

Integration of water projects to government structures and other sectors is needed. Projects that are implemented by an outside agency suffer from non-integration. In Mtwara-Lindi there is separation between the Ministry of Water and the consultant contractor. Tanzanians interviewed emphasized that they should be part of the same structure.

DISCUSSION

Mr. Odira wondered how a water project planner having a few years for the whole project could wait for community research taking a couple of years. The *Speaker* replied that a water project takes at least ten years. Therefore, we have to start building this trust and communication in the very beginning. We have to have some basic knowledge of the communities before we start the actual project. The chairman reminded about the allocation of resources. If you have to use all your resources to construct e.g. 600 wells with limited time there is not too much time for communication. If even three of them are missing someone will come and point on those ones. If you manage to construct those 600 wells someone can come and ask why you did construct the wells by yourself without communicating.

Prof. Viitasaari said that in most cases we cannot meet the people's needs although we want to. The people do not necessarily need a well as a priority but they may need a plough, oxen, school or dispensary. If we utilize deep ground water by heavy drilling rigs we are not able to go from one village to another very far away. Instead we have to follow a certain programme in the area. Among the villagers there are many whose needs we are not able to meet. In Finland over twenty years ago consultants used to announce the coming meetings for the public in newspapers and other places. This is not perhaps a common practice anymore. To introduce this kind of information system we should have it mentioned in the law.

The *Speaker* said that it is amazing how easily information travels e.g. in Tanzania. However, the separation of different development sectors makes it difficult to cooperate. It is the general mood that influences people's behaviour rather than individual cases here and there. The *Chairman* concluded that there must be some kind of incentive for the people to get them to participate.

Mr. Musyoka reminded that people cannot be happy if the water project lasts for ten years or even more. *Mr. Nyangeri* said that traditionally in planning of rural areas even wells have been sited and constructed by men. The *Speaker* replied that in Kenya 40% of households are women-headed and that times of men being the total heads of households are in the past. *Mr. Odira* commented that women have never been heading house-holds in Kenya. *Mr. Nokso-Koivisto* said that because of intercountry emigration there really are women-headed households in Kenya.

Mr. Heikki Wihuri
Soil and Water Ltd.

HYDROGEOLOGICAL POSSIBILITIES FOR WELL SITING AND CONSTRUCTION

Let me start my presentation with the claim that the well must be placed just where water is available! Any objections?

My second claim is that a dry hole is a monument of an error or several errors! Any objections?

Ground water is a very valuable renewable natural resource but it is amazing how little we know about it. We believe much more than we know. We believe in water veins, water witching and also that the law of gravity would not be valid for ground water. But in reality the laws of nature govern the occurence of ground water.

Water witching has always been one of mankind's superstitions and it is amazing how difficult these are to fight against. If you are lucky you may find water but it is not a question of knowledge or science.

Factors that govern the occurence of ground water are

- precipitation
- evaporation
- infiltration
- formation structure
- elevation
- geochemistry

Hydrology is an interdisciplinary science involving many other sciences near geology. Hydrogeology studies the occurence of ground water and the influence of ground water on formations.

Geohydrology, which is the closest nearby science, studies the behaviour of water in the ground. It gives the structure the skeleton for calculations and scientific treatment of data out of ground water and its behaviour. But this is not enough!

The movement of a single water drop can be described through a mathematical formula which is based on certain assumptions. The more complicated these formulae are the more aspects they take into consideration. But there are always some assumptions or generalizations on the origin, the development, the future and the character of the formation.

Geological formation governs the chemical character of ground water (Fig 1). Part of the substances occuring in ground water are inorganic and some of them are organic. The most simple inorganic substances are biocarbonate, calcium, chloride, fluoride, iron manganese, sodium and sulfate (Table 1).

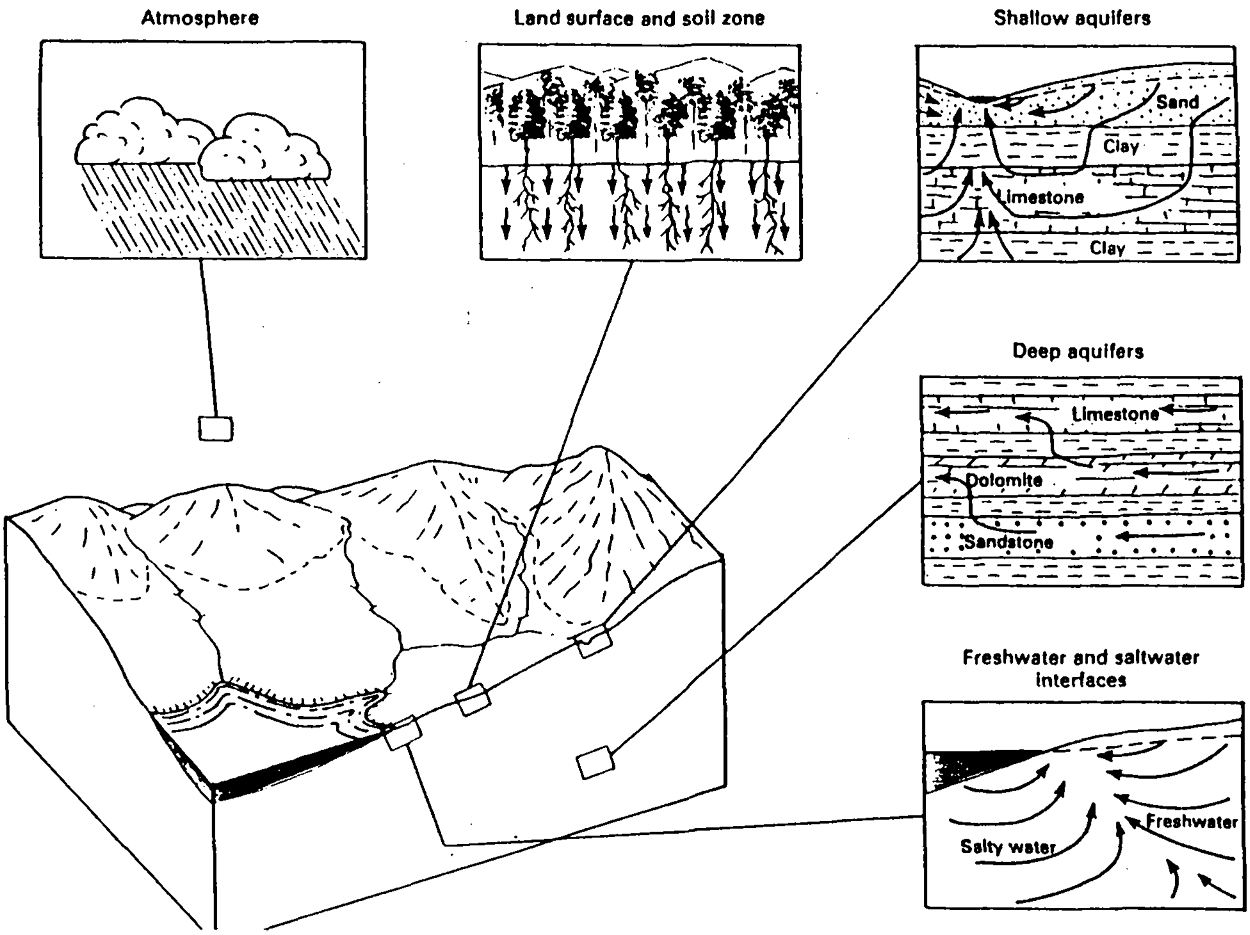


Fig 1. The chemical characteristics of ground water are determined by the chemical and biological reactions in the zones through which the water moves.

Table 1. Natural inorganic constituents commonly dissolved in water that are most likely to affect the use of water.

Substance	Major natural sources	Effect on water use	Concentrations of significance (mg/L)[1]
Bicarbonate (HCO_3) and carbonate (CO_3) ---	Products of the solution of carbonate rocks, mainly limestone ($CaCO_3$) and dolomite ($CaMgCO_3$), by water containing carbon dioxide.	Control the capacity of water to neutralize strong acids. Bicarbonates of calcium and magnesium decompose in steam boilers and water heaters to form scale and release corrosive carbon dioxide gas. In combination with calcium and magnesium, cause carbonate hardness.	150-200
Calcium (Ca) and magnesium (Mg) --------	Soils and rocks containing limestone, dolomite, and gypsum ($CaSO_4$). Small amounts from igneous and metamorphic rocks.	Principal cause of hardness and of boiler scale and deposits in hot-water heaters.	25-50
Chloride (Cl) -------------------------	In inland areas, primarily from seawater trapped in sediments at time of deposition; sition; in coastal areas, from seawater in contact with freshwater in productive aquifers.	In large amounts, increases corrosiveness of water and, in combination with sodium, gives water a salty taste.	250
Fluoride (F) ---------------------------	Both sedimentary and igneous rocks. Not widespread in occurrence.	In certain concentrations, reduces tooth decay; at higher concentrations, causes mottling of tooth enamel.	0.7-1.2[2]
Iron (Fe) and manganese (Mn) ------------	Iron present in most soils and rocks; manganese less widely distributed.	Stain laundry and are objectionable in food processing, dyeing, bleaching, ice manufacturing, brewing, and certain other industrial processes.	Fe>0.3, Mn>0.05
Sodium (Na) -------------------------	Same as for chloride. In some sedimentary rocks, a few hundred milligrams per liter may occur in freshwater as a result of exchange of dissolved calcium and magnesium for sodium in the aquifer materials.	See chloride. In large concentrations, may affect persons with cardiac difficulties, hypertension, and certain other medical conditions. Depending on the concentrations of calcium and magnesium also present in the water, sodium may be detrimental to certain irrigated crops.	69 (irrigation), 20-170 (health)[3]
Sulfate (SO_4) -------------------------	Gypsum, pyrite (FeS), and other rocks containing sulfur (S) compounds.	In certain concentrations, gives water a bitter taste and, at higher concentrations, has a laxative effect. In combination with calcium, forms a hard calcium carbonate scale in steam boilers.	300-400 (taste), 600-1,000 (laxative)

[1] A range in concentration is intended to indicate the general level at which the effect on water use might become significant.
[2] Optimum range determined by the U.S. Public Health Service, depending on water intake.
[3] Lower concentration applies to drinking water for persons on a strict diet; higher concentration is for those on a moderate diet.

The major natural sources come from the geological history e.g. bicarbonates are the products of solution of carbonite rocks, mainly limestone and dolomite caused by water containing carbon dioxide by natural or man-made acid rain. If you do not know the geological background how can you solve the problems? Not by voting!

There are various ways of producing wells like dug, bored, driven, jetted or drilled ones (Table 2). Each well construction method is suitable in certain geological conditions. Percussion drilling unlike digging, boring, driving and jetting is practical also in harder formations.

Table 2. Suitability of different well-construction methods to geological conditions.

Characteristics	Dug	Bored	Driven	Jetted	Drilled: Percussion (cable tool)	Drilled: Rotary Hydraulic	Drilled: Rotary Air
Maximum practical depth, in m (ft)	15 (50)	30 (100)	15 (50)	30 (100)	300 (1,000)	300 (1,000)	250 (800)
Range in diameter, in cm (in.)	1-6 m (3-20 ft)	5-75 (2-30)	3-6 (1-2)	5-30 (2-12)	10-46 (4-18)	10-61 (4-24)	10-25 (4-10)
Unconsolidated material:							
Silt	X	X	X	X	X	X	
Sand	X	X	X	X	X	X	
Gravel	X	X			X	X	
Glacial till	X	X			X	X	
Shell and limestone	X	X		X	X	X	
Consolidated material:							
Cemented gravel	X				X	X	X
Sandstone					X	X	X
Limestone					X	X	X
Shale					X	X	X
Igneous and metamorphic rocks					X	X	X

DISCUSSION

Mr. Ngainayo referred to the traditional use of witches in well siting and asked about their relevance compared to hydrogeological investigations. The *Speaker* replied that the degree of success depends on the scale you are working with. Water veins do not exist, water occurs as a layer all around in the ground but the water transporting capacity of the layers varies more than 10 000 times. If you construct a dug well for a few persons they get water almost everywhere. But if you are working for bigger water demand of a village or a town, hit or miss/ success or try and error methods are not good enough. The ancient belief in water veins has no scientific basis. Those people who use witching have got an eye for nature e.g. can read the signs of vegetation and they know through experience where to get water. *Mr. Nyangeri* asked about the origin of the use of witches. The *Speaker* replied that this belief seems to be worldwide and thousands of years old. *Mr. Mashauri* referred to the book "Ground Water" by Raghunath where this witching is mentioned and classified under science!

Dr. Rönkä pointed out that hydrogeology needs also other sciences like geophysics. For instance, in Tanzania a number of investigation equipment could be rehabilitated with small costs and still they would help very much in groundwater investigations and well siting. The *Speaker* highly agreed with this comment. The result is better if you have the right tools. Technology is needed as well e.g. pumps. Thus we need team work.

Mr. Ngainayo referred to the recent field visit to a drilling company where they drill to bedrock without any real siting. Where is the boundary to start using siting methods? The *Speaker* admitted that this procedure is common in Finland. However, these companies often give a quarantee, if there is no water there will be no costs to the client. The question concerns the scale of activity. In a small project you cannot afford to make proper investigations but normally for wells of one to two families they are not necessary in the conditions of this country. But if we have an arid area with less than 400 mm. annual rainfall it is absolutely necessary to use more sophisticated methods. It is a question of judgement when these methods are needed.

Dr. Swantz reminded that bussman people are the only ones who are able to live in the Kalahari desert and they know through their experience where to get water. The Masai people are used to digging their wells for tens of meters deep So there are ways to construct wells through experience. The *Speaker* replied that the knowledge of Masai is already more a part of science than poor belief. In many areas wells have been dug for thousands of years. *Mr. Katko* referred to the Holy Bible, Genesis 26 where there are arguments on ownership of wells dug during the days of Abraham. Genesis 29 tells about covering of wells which is already a sign of ground water protection.

Mr. Matti Rantala
YIT Ltd.

EXPERIENCES ACHIEVED IN ORGANIZATION OF HANDPUMP WELL CONSTRUCTION AND MAINTENANCE

1. General

The Government of Finland has assisted three countries in the development of their rural water sector. The oldest project is in Tanzania. The project started with a Feasibility Study in 1972, continued with a Water Master Plan and has been in implementation phase since 1978. Projects of similar type were started in Kenya and Sri Lanka in January 1982. All the projects include quite large surface and ground water inventories together with investigations and proposals for development of water supply mainly for rural areas. Projects have continued with implementation including the drilling of deep boreholes, piped water schemes and hand pump schemes.

The following presentation concentrates on describing experiences gathered from Tanzania in the implementation and maintenance of hand pump wells.

2. Mtwara-Lindi Rural Water Supply Project

In Tanzania the rural population is mostly living in villages, which have normally 500 to 2000 inhabitants. The village forms an economic unit which, in addition to private production, also has some commercial production. The funds acquired by the communal production of the village are used for providing various services, like health and education facilities for the community.

The water supply is seen as one of the services which are partly provided by the self-help efforts of the community. The projects, working within the field of rural water supply are, therefore, adapting their activities so that the village is responsible, either partly or entirely, for the construction, operation and maintenance of water supply systems. A functioning water supply scheme is a result of co-operation between the rural community, a governmental organization and the donor agency. However, the operation and maintenance of a rural water supply scheme should mainly be the responsibility of the community so that the degree of self-relience is maximized. The targets are especially emphasized in the new local Government Act 1982, which was put into effect in 1983.

The Government of Finland has assisted the Government of Tanzania in the development of the water sector in the Mtwara and Lindi Regions since 1972. The two regions, with a total area of 84,700 km² and a present population of about 1,25 million are among the least developed areas in Tanzania. Until now the following phases have been completed:

- Feasibility Study 1972-1973
- Housing Project 1973-1974
- Water Master Plan 1974-1977
- Implementation Phase I 1978-1980
- Implementation Phase II 1980-1981
- Implementation Phase III 1982-1984

Implementation Phase IV started in January 1985 and it will continue until the end of 1987.

3. Hand Pump Wells

By the end of 1984 the total number of hand pump wells constructed was 1780. About 800 wells are needed to complete the target which is to be completed by the end of 1987. At the beginning of 1984 the project received a down-the-hole hammer drilling rig. The rig will be used to drill medium-deep hand pump wells especially in the basement area in Masasi and Nachingwea Districts, where dug wells or auger wells cannot utilize deep aquifers and where many existing wells are getting dry at the end of the dry season.

The depth of dug wells varies from 3 to 5 m and that of auger wells from 7 to 11 m. The average pumping depth varies respectively from 2 to 3 m and from 3 to 6 m.

4. Village Participation

The villages are participating in the construction of hand pump wells as follows: the information on possible well sites is collected by interviewing the villagers during the survey. In machine dug and auger well production the villagers provide assisting labour.

Since July 1983 no payments have been made to the village for providing labour. Earlier villagers were paid 500 Tshs per well after completion. The change has caused some problems especially near those villages which have received payments before. Hand dug wells are constructed independently by villagers and the project provides only supervision (one foreman) and materials. After the construction has been completed, the whole responsibility for hand pump maintenance is gradually handed over to the village.

The villagers are informed about the well construction in village meetings. The authorities of the district are involved and division and ward secretaries participate in the meetings. Finally the agreement for the handing over of the wells to the village is made between the project and the village.

5. Village Level Operation and Maintenance

During years 1978-1982 two village caretakers have been trained for each village where hand pump wells have been completed. In practice an average of one-day training has been insufficient and mobile maintenance groups have done the main part of actual maintenance. Every well has been visited on average three times a year. With this degree of maintenance 85-90% of the hand pumps are always in working order.

During Phase III a new training programme for the village level maintenance system has been created. Those village caretakers who have already participated in the one-day training will be selected for retraining, wherever possible.

The central person in the village level maintenance system is the village well caretaker. Two caretakers are needed in every village served by shallow wells.

By the end of 1984, some 550 village well caretakers have been trained for 220 villages.

The total number of the villages to be covered is estimated to be 400.

The second link in the hand pump well maintenance system is the district maintenance centre. These centres are points for spare part distribution, technical help for village well caretakers is also available there. The district maintenance centres were completed by the end of 1984.

The regional maintenance centres of Mtwara and Lindi will co-ordinate the hand pump well maintenance of the regions. The spare parts will be shipped to Mtwara and distributed to Lindi and into district centres. The project will take care of the spare part distribution for the time being.

The project has established a follow-up system for the villages, where the maintenance has been handed over. The villages are visited frequently, once in 3 months. The work of the village well caretakers is checked and followed up and village governments are interviewed. The follow-up safaris made so far have shown that the average percentage of broken pumps is slightly higher than when the maintenance system was centralized.

The difference between different villages is greater than earlier. The percentage of operating pumps has varied from 100% to 70%, the average being 84%. A general observation has been that the better the village organization, the better the maintenance. Also those villages which implemented the well scheme on self-help basis and where the wells were never maintained by the Project, are more active than the others. Over 90% of the wells are regularly found operating in those areas. Many villages have some problems when starting the village level maintenance. The purpose of follow-up work is also to encourage the villagers to organize themselves to give more training to village well caretakers and to give technical assistance when needed. Spare parts are not distributed during the follow-up safaris, the well caretakers are encouraged to collect them from the district centres.

6. Maintenance Costs

Owing to the recent launching of the village level maintenance programme the exact figures of the costs are not available. The maintenance costs mentioned below are calculated according to the centralized maintenance system carried out by the project.

Maintenance costs are calculated on the basis of direct costs only and not including project overheads. In order to calculate the costs of spare parts, the number of used spare parts has been estimated from the last half of 1983. Previously the information collected from maintenance cards included all the spare parts used, but did not take into consideration that, for instance, cylinders are repaired in the workshop and reused. The real consumption of cylinders is quite small because more than 90% of all replaced cylinders can be repaired. As for other spare parts it has been assumed that they are replaced with completely new spares. Actually, besides cylinders, some other spares can be repaired and recycled, but repair of them has been on such a small scale that it has been considered to have very little effect on the total costs.

Table 1. Maintenance and sparepart costs of handpump wells

Spare parts	257700	Tshs	45%
Transport	200000		35%
Local labour	109000		19%
Tools etc.	4300		1%
TOTAL	571000	Tshs	100%

Maintenance costs/well	497	Tshs/well
Spare part costs/well	224	Tshs/well

7. Development of Hand Pump Technology

In accordance with the contract between the Government of Finland and World Bank the pump test started in March 1983. The aim of the project is to evaluate, compare, analyse and promote hand pump technology. The Project is monitored by a World Bank Expert. The project is providing facilities for carrying out the research work. Since it is still in its early stages, results are not yet available. The following pumps, and later possibly others, are tested: Nira, Blair, Malawi Afridev, SWN 81 and Kangaroo.

The project started experimental work with a new type of hand pump late in 1983. This direct action type pump has been designed to be as simple as possible. It uses as far as possible local skills and materials. In the simplest model only one spanner is needed for maintenance and repairs. The actual dismounting work can be done solely by removing one bolt. The cap can be opened, the the inner pipe with wooden bushes can be taken away and the piston rods can be lifted up along with the piston.

The pumps have been made by skilled local workers, using mainly imported materials. The aim, however, is to use more locally available materials, for example, the bushes have been made of wood. According to the Dutch Morogoro Project wood called mkrati is the best alternative but our own experiments have shown that African blackwood (ebenholz) is at least as long-lasting and is available in southern Tanzania. Three-month field tests have shown so far that the wearing of wooden bushes is rather fast during the first weeks but after creating considerable clearance the rate of wearing gets much slower.

Vammalan Konepaja has also developed a new direct action hand pump which utilizes plastic pipe technology and pumps on both upward and downward strokes. It is one of the hand pumps which best meets the World Bank requirement of Village Level Operation and Maintenance (VLOM) hand pump.

DISCUSSION

Mr. Nyangeri asked about the possible advantages of piped schemes compared with dug wells. How do we take into account the future demand for individual house connections with dug well system? The *Speaker* replied that the biggest advantage of piped schemes is that they can be used in such areas where it is not possible to have hand pump wells. E.g. in southern Tanzania about 50% of the population is living in these kind of areas. The policy has been such that if we can construct hand pump wells, we do not go to piped schemes because they are 3...4 times more costly. Pumped schemes are very difficult to operate in rural conditions because of lack of fuel. Individual connections are to be considered for special consumers in Western Province in Kenya.

The *Speaker* continued that the community wells are not at the moment connected to any individual houses. In the long run, separate construction of private wells should be encouraged and in this case it is also possible to have house connection. It is the question where to concentrate the construction of water supply. If we concentrate on piped schemes in Kenya it would mean that every day there will be more people without adquate water supply. But if we concentrate on handpump wells there will be certain possibilities to increase the relative portion of people served by safe water. It is the question of service level.

Mr. Musyoka agreed that the house connections are very expensive at the present stage of development in large parts of Kenya. The *Chairman's* opinion was that nowhere in the world, in no country all people are yet served by individual connections. This situation will not be true for a long time. In Finland the national objective of the water decade is to supply safe water to all the people but not necessarily by individual connections. We can have private or a few family owned wells. No government can afford serving all the population by house connections. If the population is not densely distributed it will be very expensive to construct the pipeline.

Mr. Nyangeri suggested that water supply should follow the general raise in the standard of living and improvement of other facilities. The *Chairman* proposed that you can make your own open well to improve your water supply.

Mr. Nyangeri wondered what the lifetime of a a well is. *Mr. Wihuri* answered that there has never been a mountain that had not eroded. Life expectation for a well is about 20 years. The next step after a well with hand pump will be an engine driven pump for the same well. We can also combine several wells and have individual connections to each house. By using of wells it is possible to improve the water supply system step by step. Today we cannot afford long distance transport of water by pipelines.

The *Speaker* added that in Kenya about 50% of the rural piped water schemes (excluding the gravity schemes) are not working because of several reasons. Hand pump wells are more reliable if the maintenance is properly organized. *Mr. Nokso-Koivisto* said that because both the piped system and the hand pump well are safe from the health point of view it is advisable to use hand pump wells. Additionally a piped system will always cause a problem of wastewater.

Mr. Laike asked who is taking care of maintenance and how these people are trained in Mtwara-Lindi. The speaker replied that they have two pump attendants in each village. They have got one week's training which seems to be enough, at least from the technical point of view. In practice the pump attendant is technically able to do all maintenance needed. When a breakdown occurs in a village, the pump attendant takes the broken part and goes with that to the district stores to get a new one. He gets his payment from the village so he is not paid by the government. He is responsible for his work straight to the village. In most villages there is proper and working administration and this system seems to work well. However, there are also villages which cause problems and these will drop the average level of pump functionality.

Dr. Swantz wondered if the payment is fixed. The *Speaker* answered that this is determined case by case. In some villages fixed salary is paid, in other villages payments are based on the work done and the travel expenses. *Mr. Ashenafi* wondered who pays the maintenance costs. The *Speaker* notified that up till now the spareparts have been free of charge but the aim is that the village should pay for the spareparts, at least a part of the real cost.

Mr. Katko inquired about the possibilities for local production of direct action hand pumps. The speaker said the local production of hand pumps is technically possible if there is donor support. The main problem with all types of pumps is the lack of materials which , therefore, have to be imported.

Mr. Luonsi asked if there is any regular water quality control of wells. The *Speaker* replied that the project follows the general situation in the area but is not checking every well according to fixed time table. If a lot of coliform bacteria are found, it indicates some kind of breakdown of the structure.

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