

Appropriate Technology for Water Supply and Sanitation in Rural and Peri-Urban Areas in some Countries of the Eastern Mediterranean Region



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Appropriate Technology for Water Supply and Sanitation
in Rural and Peri-urban Areas

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2. Essential features of the technologies/methods employed in supplying water and disposal of excreta/wastewater in rural and peri-urban areas of the country, with successful and unsuccessful applications of these technologies. Suitability of the technologies used, to the national needs and requirements.
3. Needs and requirements for operation and maintenance in water supply and excreta disposal systems serving rural and peri-urban communities.
4. Institutional set up in the country for providing water supply and sanitation services to the rural communities. Agencies and institutions responsible for these services.
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1. Current Water Supply and Sanitation

1.1 Background

Total area of Iran is about 1.648 million square kilometers (sq. km). The population of Iran, as of 1994 census, is estimated to be 60 million. The population was 34 and 50 millions for the years 1976 and 1986 respectively. Density of population varies from 5 to 291 with an average of 35 persons per sq. km. Over all life expectancy at birth is 67.

Jordan occupies an area of approximately 90,000 sq. km. The total area is divided into the following zones: 71.5% desert, 22.3% arid, 2.2% marginal, 3.3% semi-arid, and 0.7% semi-humid.

The census of 1979 estimated Jordan's population at 2.147 million distributed among 1017 population centers, and growing at a rate of 3.7%. In 1991, Jordan's population was estimated at approximately 3.888 millions and growth rate at 3.4%. The urban/rural population was divided at approximately 77.9% / 22.1% and the estimated nomadic population was about 7,000.

Tunisia covers an area of 160,000 sq. km. The Saharan Atlas, which runs from west to east at about 280 kms south from the northern coast line, separates the country into two distinct regions. To the north of Atlas, it is semi-arid area, where majority of the population live, with the mean annual rainfall does not exceed 600 mm. To the south of Atlas, it is an arid land with an average annual rainfall of less than 100 mm.

The population of Tunisia, in 1991 is estimated to be 8,2 millions, of which 4.9 millions are urban (60%) and 3.3 millions are rural (40%). About one-third of the urban population lives in the two largest metropolitan areas of Tunis and Sfax. Meanwhile, the rural population is widely scattered over more than 4,500 locations which are often isolated from each other and whose low population density impedes rapid implementation of water supply and sanitation systems.

Yemen occupies a largely mountainous area of about 536,000 sq. km. Its population, in 1993, is estimated at 14.5 millions of which 2.9 millions (20%) are urban and 11.6 millions (80%) are rural. There are approximately 120 urban communities and over 70,000 rural and semi-nomadic settlements.

1.2 Water Resources

Inhabitants of urban areas, in Iran, adjacent to rivers are served by a community water supply system (pipe water) for drinking and other uses. Accordingly, Tehran, Karaj, 9 cities of East Azerbaijan, one city in Gilan, 17 cities in Khusistan and two cities in Kerman are served by river sources.

In some parts of Iran, mostly in rural areas, water is supplied from protected dug-wells and the water is then chlorinated in Urban areas and some is not treated in rural areas.

In some rural areas of Sistan and Bluchestan, Fars, Boushehr and Hormozgan Provinces, the rural dwellers use chlorinated rain water collected in ponds or cisterns

For the year 1992, total water supplies in Iran was 2.9 bcm, from which 64.4% has been derived from groundwater resources and 35.6% from surface resources. According to present data, 4.7% of all water used is for domestic and industrial uses. Water use in 1992 has been estimated to be 236 l/c/d which shows 9% increase during the last 3 years.

Reservoirs capacity are 5.5 MCM, in addition to 0.9 MCM under construction. Approximately, one MCM reservoirs are in rural areas.

Jordan's water resources are groundwater and surface water. Groundwater is considered the most reliable source for water supply in Jordan. Currently, groundwater sources provide most of Jordan's municipal and industrial water supply, and almost half of the total supply for irrigation. In 1990, the total water supply was approximately 880 MCM of which 520 MCM were from groundwater sources (150 MCM for municipal, 329 MCM for irrigation, 35 MCM for industry, and 6 MCM for livestock).

In 1990, groundwater over-pumping in Jordan was estimated at 155 MCM/year. Over-pumping resulted in the deterioration of the water quality of some aquifers and eventually their dry-up. Consequently, many wells became inappropriate for water supply and were abandoned. Brackish water aquifers are also being considered as source of water supply in the country. Desalination of brackish water is currently being considered to supplement the country's increasing water demand.

There are two major surface water basins in Jordan. These are: the Jordan River and the Yarmouk River basins. The Yarmouk River basin, also shared with Syria, provides approximately 40% of Jordan's surface water supply. The utilization of Jordan's River is to Jordan's disadvantage. Other smaller surface water sources (dams, reservoirs) are spread all over the country. Surface water supplies a significant portion of Jordan's total water supply. In 1990, total surface water supply was 360 MCM, or 41% of the total: 30 MCM residential, 322 MCM irrigation, and 8 MCM industrial.

In Tunisia, the annual total volume of exploitable water resources amounts to 3.8 million cu. m. of which 70% is already tapped, including 10% for potable water. By the year 2000, more than 90% of the resources will be in use, with 22% for potable water. Most of the fresh surface water resources are, however, found in the north-west, requiring large impounding reservoirs to optimize their yield and long mileage of pipes to convey their water to the consumption centers. Groundwater resources in the north have limited capacity, making them only suitable for potable water supply to small towns. Generally, surface water is used for the supply of the large cities in Tunisia.

Yemen relies mainly on groundwater and valley water for its water supply. This sole source is in short supply due to heavy irrigation use (90%).

1.3 Water Supply

1.3.1 Water Supply in Iran

At the present time, the total annual water supply for rural areas is estimated at 600 million cu.m. with a water use of 10 to 150 l/c/d (10 l/c/d is for the people who take their drinking water from public taps or small individual source of water). Ministry of Construction Crusade is responsible for the water supply systems in rural areas since 1991. The average community participation for rural water supply investment is around 30%. At the present time, more than 25 millions of rural inhabitants live in 65,000 villages of which, 40,000 villages have population less than 200 inhabitants. About 86% of the rural population are served by 28,000 water supply systems and 4,000 protected water sources by the year 1994, mostly were executed by the General Department of Environmental Health in the Ministry of Health and Medical Education.

By the end of 1992, there have been 5.37 million units of inhabitants water users in Iran which cover 30 millions of urban people. About 91.5% of the urban population are served by water supply networks. The other 8.5% have indirect access to urban water networks. And, because the system (55,000 kms) is old, about 25% of the supplied water is lost in the network.

1.3.2 Water Supply in Jordan

The major components of Jordan's national water supply system are summarized in Table 1. The consuming sectors are municipal, commercial, industrial, agriculture, and livestock. In addition, a significant portion, exceeding 35% of the pumped water is wasted throughout the distribution networks. Water sources are ground water, river and spring water, rain catchment, and reclaimed treated municipal and industrial wastewater. The components of public potable water supply include: source development; water transportation from source to treatment and to storage facilities; storage facilities; pumping facilities; treatment facilities; and water distribution networks. The Water Authority of Jordan, as part of the Ministry of Water and Irrigation, is directly responsible for supplying water to consumers. The Jordan Valley Authority, also part of the same Ministry, has full authority on water resources under its jurisdiction in the Jordan Valley. Many other participants are involved, directly or indirectly, in some aspects of national water supply including Government Organizations (GOs) and None Government Organizations (NGOs). The major aspects of their contribution and inter-agency collaboration are discussed in a following section.

Table - 1: Major Components of Jordan's Water Supply System [Table-4, (3)]

Consumers	Supplier	Sources	Potable Water Treatment	Potable Water Storage	Potable Water Distribution
-Municipal -Industrial -Irrigation -Livestock -Loss & Waste	-The Ministry of Water and Irrigation through The Water & The Jordan Valley Authorities	-Ground Water -Surface Water -Rain Catchment -Treated Wastewater	-None -Chlorination Only -Aeration/Coagulation/ Filtration -Conventional Treatment	-Public Storage -Residential roof-top tanks	-None -Standposts -Tankers -Networks

1.3.2.1 Potable Water Supply

Jordan is dominated by arid conditions. The scarcity of water resources in Jordan is alarming, especially when other water supply constraints are considered, including: financial difficulties; rapidly growing population; fluctuating rainfall patterns and its concentration on the narrow mountainous region; expanding industrialization; urbanization; and lack of regional water use cooperation. Accordingly, the scarcity of water resources continues to have a significant impact on Jordan's economic, social, and welfare development. Nevertheless, aware of the scarcity of the resource, Jordan achieved, and continues to achieve, significant steps towards efficient use of available resources through management and optimization practices. A significant portion of the government public sector investment is typically allocated for water and irrigation.

The quantities of water supply for municipal agriculture and industrial purposes in Jordan were as estimated in Table 2. The data indicate that the largest water consuming sector in Jordan is agriculture, followed by municipal, industrial and livestock.

In 1990, the total water supply was approximately 880 MCM (255 CM/Capita) which represented 93.3% of the amount allocated for the same year. A minimum demand of approximately 1350 MCM is projected for the year 2005, not taking into account the full impact of the recent gulf crises.

Table - 2: Quantities of Water Supplies (MCM) (Jordan), [Table-6, (3)]

sector	1979 ³	1982 ³	1990 ¹	1992 ⁵
Municipal	50	59	180	208
Industrial	8	15	43	-
Agriculture	406	416	651	-

Currently, almost all, 97%, of Jordan's population have access to safe water supplies through pipe connections. According to the data in Table 3, residential water supply increased from 77.4 MCM in 1984 to 208 MCM in 1992. Municipal demand is expected to continue to rise to reach approximately 320 MCM by the end of the decade.

Remote, seasonal communities, rural and urban fringe areas, and nomads typically utilize water supply systems such as: water supply by tankers from public and untreated stream and spring water sources, rain water harvesting, and private wells. For such users, nearby safe water is generally available, however at a higher cost and lower convenience than traditional sources. Nevertheless, the unreliable nature of the traditional sources encouraged the demand for public water supply in all parts of the country.

According to the above discussion, the targets for the previous water supply and sanitation decade were achieved, to a large extent, in terms of water supply systems by the early 1990s.

Table - 3: Residential water Supply (Jordan), [Table-6, (3)]

Year	Amount (MCM)	No. of Connections (Thousands)
1984	77.4	266.3
1985	93.0	334.3
1986	134.6	364.3
1987	150.5	399.7
1988	164.8	422.5
1989	170.2	441.2
1990	178.6	460.2
1991	178.6	478.9
1992	208.0	502.5

1.3.2.2 Quality of Water Supplies

Jordanian Government, through its various departments, supplies potable water to consumers and alone guarantees its quality. The quality of potable water supply is a top priority issue for The water Authority of Jordan which continues to achieve significant water quality improvements. The above trend is reflected in the number of water samples collected between 1986 and 1992, as shown in Table 4. The Annual failure of potable water samples was reduced from 24.3% in 1972 to approximately 2% in 1989.

The Water Authority, through its central laboratories, continues to improve its capabilities and quality assurance/quality control methods (QA/QC) through programs and activities including:

1. Improving the capabilities of analytical laboratories by providing them with the necessary hardware, chemicals, and experienced personnel.
2. Improving and expanding the monitoring network.

In addition to monitoring the quality of potable water, The Water Authority monitors the quality of effluents from wastewater treatment plants, industrial discharges, and the quality of streams and water reservoirs.

Table - 4: Water Samples and Analyses (Jordan), [Table-7, (3)]

Year	Number of Samples	No. of Analyses
1987	12310	71591
1988	15872	95923
1989	23391	122750
1990	27541	118796
1991	23972	112527
1992	22011	103550

The Ministry of Health is responsible for all matters related to health in the country including monitoring the quality of drinking water. The Ministry of Health has the authority to stop the distribution of unhealthy water. In case of an epidemic, the Ministry is responsible for taking all necessary steps to stop the spread of disease, including monitoring public and private water sources. The Ministry has also the right, by law, to supervise the construction and operation of water supply systems and stop disposal of wastes or other activities that may contaminate drinking water resources. The water quality reported by the Ministry in the period 1980 to 1990 exceeded WHO standards between 1980 and 1986 and were within acceptable limits during the last 4 years of the previous decade, thus implying continued improvements in potable water quality. The number of collected and tested samples by the Ministry increased from 4,575 in 1980 to 41,256 in 1990.

1.3.2.3 Distribution of Water Supplies

Water distribution is mainly accomplished using pipe networks and house connections. Supply of water by tankers is also used in some areas, and in urban areas during summer periods of interrupted water pumping.

Currently, the supply does not meet the desired demand for water and accordingly, water rationing during the dry season is typically practiced in some parts of the country. Periods of interruption in pumping and loss of pressure lead to potential complications in the water supply networks including fatigue, corrosion, increased loss and wastage, and increased opportunities for contamination. Another effect of interrupted pumping is the increased dependence on water supplies from tankers which may, some times, come from unsafe sources. Although studies that relate the effects of interrupted pumping on human health are not locally available, it is logical to assume that the potential risks of contamination and infection are increased. The estimated losses from water distribution networks exceed 35%.

Most residential units have rooftop storage tanks with typical minimum storage capacity of two days of household water supply. The use of such tanks is a necessity and a requirement in urban areas. Sometimes, additional ground level storage tanks or drums are used, in addition to rain water harvesting in private wells.

1.3.3 Water Supply in Tunisia

About 6 million are supplied by SONEDE. This amounts to 73% of the total population, distributed as follows:

- 4.9 million i.e. the total urban population;
- 1.1 million i.e. 33.3% of the rural population.

The DGR supplies about 1 million people, i.e. 30% of total rural population.

SONEDE intervenes in the urban and the densely-populated rural zones, whereas the DGR supplies potable water mostly to scattered population in the rural areas by means of public fountains. In 1991 the situation of potable water supply was as follows:

- 100% of the urban population (4.9 million) were served by SONEDE;
- 33% of the total rural population (1.1 million) were served through SONEDE;
- 30% of the total rural population; (1 million) were served through the DGR;
- Access of the remainder (37%) to drinking water is difficult.

Here, we are mainly interested in the supply of water to rural zones, since the supply of urban zones is self-evident.

The operation of the different rural water supply systems depends on the type of rural population (concentrated or scattered) and on the type of operator (SONEDE*, DGR**).

1.3.3.1 Water Supply to Rural Areas by SONEDE

The rural water supply network installed by SONEDE is designed to satisfy the needs of the users. The quantity of water supplied to households is sufficient for individual hygiene needs (20 to 25 liters per day).

The low water rates encourage customers to use the quantity required for drinking and other domestic needs. The connection to individual dwellings consists initially of one tap in the courtyard. Later on, some dwellings will have another tap in the kitchen or the shower room installed.

There is financial encouragement to low-income consumers by making credit available for connection costs: the cost of connection to the water system could be spread over 10 years interest-free until 1972, thereafter SONEDE reduced the credit to five years at commercial interest rates.

As a result, the number of customers has been increasing, on average, by 13.6% a year.

By the end of 1991, the number of customers was 1 million. The decentralized structure of SONEDE at the regional level has resulted in an efficient network operation: maintenance, repair, extension, new connections.

Throughout the SONEDE network, bacteriological water control is carried out systematically, showing about 96% of samples safe.

1.3.3.2 Drinking Water Supply for Scattered Rural Population

Conditions are less favorable for scattered rural populations or those living in small settlements with less than 100 inhabitants, supplied from public or private wells from which water is drawn using pails and rope, thus limiting the quantity of water used to the strict minimum (an average 3 to 5 liters per day per person for drinking purposes). This water is of uncertain quality, despite occasional disinfection of public wells by Ministry of Public Health employees. As there is no Health Education Program, disinfection in homes is not common practice, despite the free distribution of disinfection tablets by the Ministry of Public Health. Because of the long distances they have to go, some people who are far from wells purchase their requirement, from water vendors (500 liter-cisterns drawn by animals) at prices of up to ten times the cost of water from the stand pipe (about US\$ 5.00 / cubic meter).

* Societe Nationale d' Exploitation et de Distribution des Eaux,
(Water Utility Company)

** Direction du Genie Rural, (Department of Rural Engineering).

1.3.3.3 Drinking Water Supply by "Direction Du Genie Rural" (DGR)

Somewhere between the above extremes we find systems constructed by DGR, PDR*, PDRI** etc... or with financial support from UNICEF, USAID etc.. the volumes of water drawn from public stand-pipes are generally adequate for concentrated populations within a radius of 3 to 4 km, but much less in the case of scattered populations. Here again, vendors carry water in drawn cisterns and sell it for a high price. Therefore, only the minimum is bought. Water supplied is generally of good quality, and is periodically checked by the Ministry of Public Health. Many of these systems include a health education components encouraging users to apply disinfection in their homes.

1.3.3.4 Water Supply Prospects (VIIIth Plan: 1992-1996)

In urban areas where 100% of the population are connected to the water supply system, it is forecast that 586,100 new people over the 1991 figure (plus 2.3% p.a on average) will be served by the Utility, bringing the total population connected by 1996 up to 5.5 million.

In rural areas, the population served by SONEDE is forecast to reach 1.3 million in 1996, against 1.086 million in 1991, i.e. an overall increase of 214,000 people of which 156,000 new customers distributed over 357 new rural centers. The coverage rate would then be 37.3% in 1996 versus 32.9% in 1991.

* PDR : Rural Development Program

** PDRI: Integrated Rural Development Program.

a- Connections:

For the whole of Tunisia, the population connected to a water supply system is expected to reach 66.2% of the total population by 1996, i.e. 87.5% of the population living within areas covered by a network, compared to 61.1% and 83.6% in 1991. The population connected in 1996 will be 5.959 million i.e. 936,000 individuals more than in 1991.

In urban areas, the proportion of connections is expected to rise from 90.7% in 1991 to 93.5% in 1996.

In rural areas, the absolute connection rate (connected population over the total population) will be 32.2% in 1996 against 17% in 1991, while the relative connection rate (connected population over the population covered by the network) will be 64.2% in 1996 against 51.6% in 1991.

b- Users:

The total number of SONEDE customers is forecast to reach 1.272 million by 1996, i.e. an increase of 275,000 over 1991 or 5% on average per year.

c- Network Extension:

For the 1992-1996 five-year period, SONEDE is planning to lay 3,800 km of new pipe i.e. an average of 760 km p.a.

d- Water Consumption:

The volume of water sold and billed by SONEDE would go up from 196.1 million cubic meters in 1991 to 216.5 in 1996, thus showing an average annual growth rate of 2%, which is slower than the rates observed over the last development plans (4.5% in 1982-1986 period and 2.2% in the 1987-1991 period). The campaign for water saving, the low consumption level of new customers and the different effect of sliding scale charges for water, are all responsible for the slowing down of the demand for water.

1.3.4 Rural Water Supply in Tunisia

1.3.4.1 Goals for the Water and Sanitation Decade

The United Nations has proposed "clean water and adequate water disposal for all by 1990" as a worldwide target for the 1981-1990 water decade.

The major portion of this increase would be for rural populations. The criteria for adequate water supply fixed by WHO are: a water point within 200 m (500 m in rural areas), serving not more than 250 (500) persons; a tap serving not more than 25 to 125 people and 20 to 60 liters of water per capita available daily. For waste disposal, the criteria vary according to social and ecological conditions, but are designed to reduce contamination of drinking water, bathing places, cooking utensils and food.

The Tunisian Government's response to the UN proposal was formulated in a short document entitled "National Report on the International Water and Waste Disposal Decade", prepared by the Ministry of Agriculture. The document sets out the following objectives:

- For urban dwellers, to ensure that the needs of the major centers are met by 1990 and to improve the supply to secondary centers without increasing the cost of service disproportionately in relation to general development needs;
- For rural dwellers, to increase the density of water points in order to satisfy the needs of dispersed populations, to improve the quality of water by better drawing equipment and better upkeep thereof, and to supply areas without groundwater with small reservoirs, piped supplies and public taps;
- For all inhabitants, to facilitate access to water by making credit available for connections as well as subsidies and credits for rural private water points (including irrigation); in addition, the water tariff for small consumers is to be kept low.

The report also expresses the intention of establishing a master plan for eventually providing service to the whole of the sector. It briefly mentions training and explains sources of finance for this sector in some detail. The report is however silent on waste disposal.

1.3.4.2 Rural water Supply at the start of the Decade

Although progress on extending service in the water supply sub-sector has been considerable, some 38% of the population remains without reasonable access to piped water supply. It is likely, however, that most of the 38% is made up of rural inhabitants, who are not reachable with piped water systems at reasonable cost. It is estimated that about one-third of Tunisia's inhabitants live in communities of less than 500 people or on scattered farms and small holdings, obtaining their water from shallow wells, irrigation channels, cisterns or (where available) the nearest stand-pipe. Since high per-capita costs rule out piped systems for such communities, water has sometimes to be carried long distances from dubious sources, with consequent risks. There should undoubtedly be scope for projects to protect or enclose water sources and to improve wells.

The Tunisian authorities admit that, until recently, the rural part of the sector has been neglected. The problems which have hitherto beset the sub-sector are stated as follows:

- Lack of an institutional framework, and unsuitability of civil service procedures to speedy development;
- Difficulty of adequate maintenance of installation (e.g., lack of spare parts, diffuse responsibility for repairs);
- Lack of revenues from the service;
- Poor quality of ground water and pollution of surface resources;
- An apparent disregard of the importance of clean water by the rural population.

However, the last difficulty seems to be disappearing and the Government reports an enormous increase in the demand for water in rural areas. The spread of mass communications is making the villager aware of some of the amenities he lacks and water is now his first priority.

1.3.4.3 Specific Solutions Adopted

A campaign of decontamination against cholera, initiated in 1972-1973, for which WHO provided credit for well decontamination and other purposes, also led to the initiation of a Rural Development Program. The Program is implemented by the provincial "governorate", with technical advice from the Ministry of Agriculture's Genie Rural Directorate (DGR) and has placed growing emphasis on water supply. Although the amount spent tends to depend on the availability of funds from other programs, the program has received some T.D. 2 million a year, with little outside help, a part from some wells financed by USAID and by Sweden. Sweden is also supplying appropriate technology and a new hand pump design. DGR has itself carried out some work, but on a comparatively small budget, and the total expenditure in the fifth plan period for both programs is said to have been only about T.D 15 million, i.e. less than a tenth of SONEDE's investments over the same period.

About 1800 water points were constructed or improved, 900 wells were decontaminated and equipped with hand pumps, and simple water systems were constructed in about 260 rural centers.

In 1980, however, DGR began to tackle the problem more systematically by designing regional rural water supply schemes.

In the sixth plan (1982-1986), T.D 42 million requested to supply 450 localities. Although much expanded compared with the past, the program is still relatively small compared with the needs. DGR estimates that there are no less than 4,000 villages to be supplied, in addition to the scattered population.

1.3.4.4 Master Plan For Rural Water Supply

In view of the situation described above, the Government decided to formulate a Master Plan for rural water supply.

SONEDE collected data about populations living in centers with a population of 50 to 500 within a 15 km radius: around 4000 centers were covered by this survey. This survey was conducted by SONEDE staff, with the collaboration of DGR and local authorities.

The form used for the enquiry determines for each agglomeration:

- Socio-economic characteristics and future activity;
- Existing water resources and the work required for simple water supply systems.

These agglomerations were classified into:

- Centers located near SONEDE water supply systems;
- Centers on which we have some information about water resources (it is necessary to determine the quality and quantity of this water);
- Centers on which we have no information about water resources.

The rural dispersed population has not been included in this inquiry. These people obtain their water from different sources:

- Private or public cisterns;
- Private or public wells;
- Wadis, irrigation channels.

The total number of water points is estimated at 60,000 of which 7,700 are public points.

This survey was the basis of a preliminary master plan of rural water supply.

1.3.4.5 Present Situation

This special attention paid to this sector has allowed Tunisia to achieve the results detailed below: out of a population of 8.2 million in 1991 (for 4.9 in urban areas, i.e. 59.9% and 3.3 in rural areas, i.e. 40.1% of the total), close to 6 million i.e. 73% of total population are supplied with drinking water by SONEDE and about 1 million, i.e. 12.7% are supplied by DGR.

In rural areas 33% of the population, i.e. 1.1 million, were supplied by SONEDE while 31.6% are estimated to be covered by DGR. The overall rural supply rate was therefore 63% in 1991.

Though supplying rural areas with water has been a major concern, a lot remains to be done, despite the considerable efforts made to date. Government authorities, at the highest level, are well aware of the need to improve the quality of life of these populations and funds for the President's Program would come on top of the finance already earmarked for the purpose in the VIIIth plan.

1.3.4.6 Future Prospects: 1992-1996 Development Plan

We will start with the two largest entities responsible for rural water supply: SONEDE and DGR.

SONEDE: Its program provides for supplying 428 rural centers including 59 renovations and 172 rural centers covered by the President's special Program. Investments provided for under the VIIIth Plan amount to 26.311 million diners, plus investments under the President's Special Programs, which are estimated at 19.841 million diners.

D G R: Total investment allocated to DGR under the VIIIth Plan are 87.2 million dinars to provide water for 965 localities (507,000 inhabitants), of which 70 million dinars for new works.

Table 5 below shows the figures forecast for rural water supply.

Table - 5: Shows the Figures Forecast for Rural Water Supply (Tunisia) (4)

Y E A R	1992	1993	1994	1995	1996
TOTAL RURAL POPULATION (Millions)	3,337	3,376	3,415	3,455	3,496
SOMEDE-SUPPLIED (Millions)	1,064	1,114	1,162	1,194	1,245
D.G.R-SUPPLIED (Millions)	1,101	1,165	1,233	1,304	1,382
PERCENT SOMEDE SUPPLIED	31,9%	33,0%	34,0%	34,6%	35,6%
PERCENT D.G.R SUPPLIED	33,0%	34,5%	36,1%	37,7%	39,5%
OVERALL POPULATION SUPPLIED (%)	64,9%	67,5%	70,1%	72,3%	75,1%
NUMBER OF LOCALITIES SUPPLIED	994	1.079	1.148	1.209	1.317
SOMEDE INVESTMENT (1,000 dinars)					
- VIII th Plan	6.497	4.778	4.986	5.798	4.253
- PRESIDENT'S SPECIAL PR.	1.196	5.687	5.318	4.750	2.890

* Does not include the President's special programm (as at Oct 10, 1992).

1.3.5 Water Supply in Yemen

As shown in the following table the percentage of service coverage in both urban and rural areas (1993).

Table - 6: (5)

Urban			Rural		
total pop. in million	pop. served in million	% served	total pop. in million	pop. served in million	% served
2.9	1.74	60	11.6	5.5	47

Future needs are summarized as projected services for year 2010 in the following table which presents the filling of gap in existing services and providing sufficient water to sustain continuous service.

Table - 7: (5)

Urban			Rural		
total pop. in million	pop. served in million	% served	total pop. in million	pop. served in million	% served
5.67	5.10	90	17.91	12	67

1.4 Sanitation

1.4.1 Sanitation in Iran

At the present time, total Iran urban water use is estimated 2.9 bcm. If 75% is converted to wastewater, total volume of the available wastewater will be 2.2 bcm. The required capital for wastewater treatment is so high that is not possible for country to invest in a limited period of time.

Fortunately, land and climatic condition in Iran is so favorable that traditional way of wastewater disposal is effective for the present demands. Ninety nine percent of urban population have access to sanitary facilities of excreta disposal, but wastewater collection and disposal is a major sanitary problem in a group of towns and cities.

Iranian cities are categorized in four groups according to wastewater disposal:

- a- Cities in which natural land and climate is favorable for soak well system:

About 200 cities (31% of total urban population) most of them small towns are located in this group.

- b- Cities in which old sewers are appropriate for the whole or part of the town:

However main collectors and wastewater treatment plants will be effective to improve environmental quality. The number of the towns in this category are 70 (5% of total urban population of the country), there are 3500 kms of wastewater collector lines which cover 300,000 users (House connections) in the above mentioned cities.

- c- Cities with modern wastewater system:

Only limited number of cities are grouped in this category. Number of users (House connection) and total length of the network are 202,000 (3% of urban population) and 2900 km respectively).

- d- Those cities in which water table is high or soil permeability is so low that soak well application is not practical. Because of health problems, these cities are in immediate need of wastewater collection and treatment system plants. The number of cities in this group are 230 (61% of total country urban population). Wastewater disposal systems in this group is soak well, cesspool, septic tanks, or direct discharge into the surface water or sea.

In the rural areas, 45% of population have access to sanitary facilities of excreta disposal, but sewerage and sewage treatment has not yet been well experienced significantly.

So far 30 wastewater treatment plants, with the capacity of 650,000 cubic meter per day have been established. Total population which are covered by these plants are 3,400,000

Treatment method is usually simple, with low cost and energy. But in those areas that land and climate are limiting factor, more advance methods should be applied.

Because of water scarcity in the country, reuse of treated wastewater is under consideration. Construction, operation and maintenance costs of the water supply, wastewater treatment plants and sewerage system is paid by the Government, but consumers and beneficiaries are charged a portion of the costs.

1.4.2 Sanitation in Jordan

On-site and off-site excreta disposal methods are used in both urban and rural Jordan. A summary of the components of the locally used sanitation systems are presented in Table 8.

Table - 8: Components of Jordan's Sanitation Systems. [Table-8, (3)]

Deposition	Holding	Collection	Treatment	Disposal	Utilization
Squatting	-Seepage Pit	-None	-None	-Land	-None
-Covered	-Septic Tanks	-Tanker	-Pit Digestion	-Surface	-irrigation
-Pour Flush	-Vaults	-Sewers	-Stabilization	Water	
Seats			Ponds	-Ground	
-Pour Flush			-Conventional	Water	
-Cistern Flush			Treatment		

1.4.2.1 Level of Sanitation Services

Until recently, most of the residential waste disposal methods used in urban and rural areas were on-site disposal, including the use of lined and un-lined cesspits and septic tanks, with the liquid effluent from such units seeping into the soil through open-jointed pipes or openings in pit walls. In 1985 (Table 9), approximately 45% of the urban population was connected to public sewerage, while the remaining urban population used cesspits and septic tanks. Cesspits and septic tanks are widely used in rural areas. At the present time, approximately 58% of Jordan's population are connected to public sewage collection systems, in urban areas. The percentage of the population to be connected to public sewerage is expected to increase to approximately 70% by the end of the decade, to cover most of the urban areas. The expansion of wastewater collection services is indicated by the number of house connections and the amount of collected and treated wastewater between 1986 and 1992, as presented in Table 10.

Table - 9: Wastewater Services in 1985 (Jordan), [Table-9, (3)]

Item	Urban	Rural	Country
Public Sewerage	45%	0	31%
Septic Tanks and Cesspits	54%	90	65
Other	1	10	4

Table - 10: Expansion of Wastewater Services (Jordan), [Table-10, (3)]

Year	Amount Treated (MCM)	No. of Connections (Thousands)
1986	22.1	
1987	27.33	58.3
1988	34.58	74.9
1989	39.86	90.55
1990	43.7	101.0
1991	45.46	107.0
1992	48.66	111.843

Until recently, the extensive use of on-site excreta disposal using seepage pits in high density urban areas resulted in many difficulties, including:

1. groundwater contamination;
2. pit overflow and associated aesthetic and health risks;
3. the need for frequent emptying using mobile vacuum tankers, with possible uncontrolled illegal disposal; and
4. spills and odors.

In rural areas, rural sanitation methods including privies, pit latrines, lined or un-lined cesspits with minor coverings, and septic tanks are typically used. The recent expansion of water supply services to rural areas was not accompanied with organized plans for the disposal of the resulting wastewater.

1.4.3 Sanitation in Tunisia

1.4.3.1 General

Prior to the setting up in 1974 of the national body charged with sanitation (Office National d'Assainissement: "ONAS"), sanitation was the responsibility of municipalities where sewage systems existed.

Because of the pressure of the requirements generated by the growth of urban development and tourism, the Tunisian government decided to create an independent authority to be responsible for the sanitation sector: ONAS.

At its inception, ONAS was placed under the supervision and direction of the Ministry of Public Works and Housing, and since 1990, it has been under the new Ministry of the Environment and Land Use Planning. ONAS is able to be of better service to the public because of its decentralized structure. It is headed by a Chairman and CEO under the direction of a Board of Directors which includes representatives of the various ministries concerned by sanitation as well as representatives of the larger municipalities.

Under the terms of its mission, ONAS covers the whole of Tunisia for the following: design, new construction and operation. In addition, it is progressively taking over existing network.

The mission of ONAS includes water environment protection:

- Insure a better quality of life through the collection, evacuation and treatment of wastewater.
- Install sanitation infrastructure in all regions of Tunisia and in particular in economic development zones.
- Conserve the country's water resources.
- Determine the best uses for by-products of sewage treatment plants.

1.4.3.2 Rural Sanitation

The 1984 census confirmed the magnitude of the rural sanitation problem: 83% of dwellings discharged their wastewater in the open, only 32% were connected to a sewerage network and 13.5% had a cesspool.

With regard to personal hygiene, the census showed that less than 29% of rural dwellings had a toilet, compared to 92% in urban areas.

It is currently estimated that more than 20% of the rural population have adequate sewerage.

In view of the tendency of scattered populations to cluster more closely together and of the rapid growth of connections to the SONEDE water supply network, the issue of the safe evacuation of wastewater is becoming a matter of pressing concern. It is widely known that from a cost/benefit point of view sewage systems in small villages, and even in larger ones, are not viable.

For personal sanitation, the rural population is not used to public latrines. However, family latrines when they are well designed and constructed, with the participation of those concerned, go down well everywhere.

It is hoped in the next few years to substantially increase the proportion of households who will build and use latrines.

1.4.3.3 Current Status of Sanitation in Tunisia

The population covered in 1991 is 3.6 million which corresponds to 430,000 users, i.e. a connection rate of 75% in the towns having a network, or an average rate of 56% for the whole country. The network operated consists of 4800 km of pipe of varying sections, 190 pumping stations and 25 treatment plants. This system currently covers 5 tourist zones and 56 municipalities.

Annually, 170 km and 15,000 new connections are achieved.

The volumes of water collected is 106 million cubic meters per annum, of which 90 million are recycled into farming (fruit-trees, forage crops).

1.4.3.4 Sanitation: Forecast for the End of the VIIIth Plan (1996)

The population connected to the sewer system will total 4.35 million, which is equivalent to an 80% connection rate for urban areas with ONAS systems (62% of Tunisia).

The network operated by ONAS will consist of 5,500 km of pipe, 220 pumping stations and 68 treatment plants. The number of ONAS customers is expected to be about 560,000 and the volume connected 125 million cubic meters while the volume treated is 115 million cubic meters.

The figures below are evidence of the country's determination to equip itself with a modern sanitation infrastructure as soon as possible. This has been a constant concern for ONAS ever since it was set-up and the total funds set aside for sanitation have been rising steadily as follows:

- 4th Plan: 1973-1976: 29.4 Million Dinars; (TD 1.000 - US 1,00)
- 5th Plan: 1977-1981: 58.3 Million Dinars;
- 6th Plan: 1982-1986: 90.7 Million Dinars;
- 7th Plan: 1987-1991: 135 Million Dinars;
- 8th Plan: 1992-1996: 200 Million Dinars, (Forecast).

1.4.4 Sanitation In Yemen

1.4.4.1 Background

Only part of the urban population is served by sewerage system in some major cities of Sana'a (25%), Taiz, Hodeidah, Ibb, Dhamar, Greater Aden (80%), and Mukalla (60%). The total urban population is 2.9 million and only 1 million people are served (34%). Therefore, there is a need to improve the sanitation system in urban areas by extending the sewerage system to cities and towns.

1.4.4.2 Sanitation in Rural Areas

There is no specific way for sanitation in the rural areas. No plan or program exists and no concerned authority to take care of the problem. Most households decide on their own how to dispose of their wastes. Sanitation is completely neglected which may result in the spread of diseases. Therefore, the need is urgent for a proper system of sanitation in the rural areas.

Based on unpublished report by UNICEF, less than 10% of the entire rural population are using safe sanitation facilities.

The establishment of a number of rural water projects with the absence of proper sanitation has created problems. The villages began to extent plastic pipes from their houses out to roads, canals, and valleys which will have health concerns and increase the danger of spreading diseases.

Appropriate Technology for Water Supply and Sanitation in Rural and Peri-Urban Areas

Introduction:

The target of the International Drinking Water Supply and Sanitation Decade (1981-1990) was to provide access to safe drinking-water and adequate sanitation for all people by the year 1990. Unfortunately, the decade targets set by most Member States in the Eastern Mediterranean Region (EMR) were not met in full, especially in rural areas. Therefore millions of people in the region are still without any safe drinking-water and adequate sanitation facilities. The main constraints that hampered the achievement of decade target were and still continue to be: depending on inappropriate advanced technologies; institutional weaknesses (especially in rural areas); the scarcity of water resources in the Region; lack of community involvement and participation; lack of sufficient and trained personnel in this area; Non - decentralization of rural water supply and sanitation schemes at the community level; lack of environmental health awareness; absence of women education in personal and domestic hygiene and participation in water supply and sanitation schemes; and inadequate national infrastructure and legislation for such schemes.

About 60% of the EMR population lives in the rural areas, where water supply and sanitation coverages are only 41% and 18% respectively. In order to meet the "Health for All" goals by the year 2000 (HFA 2000) a well integrated approach amongst water supply and sanitation agencies, primary health care programmes and the community-level management is essential. The "top-down" planning approach makes the community reluctant to develop any sense of ownership or responsibility for the operation and maintenance for any system. The imported technologies are, usually, not appropriate, affordable, suitable and sustainable for the communities.

The successful operation and maintenance of rural water supply and sanitation systems also depends on the customers' ability and willingness to pay for services. Experience has shown that where the "user-pay" principle is properly implemented, the responsible authority is able to develop its staff, infrastructure, administration, capital works and maintenance capabilities, which ultimately enables it to provide efficient services.

In order for every nation to aspire for "healthy people in the healthy environment" goal, simple, appropriate and sustainable water supply and sanitation technologies and systems must be identified and adopted, meeting the local needs and EH conditions.

The EMR States were invited through 30 December, 1992 to 30 January, 1993 to prepare a study on "Appropriate Technology for Water Supply and Sanitation in Rural and Peri-Urban Areas". Only four reports were received from the following states: Iran, Jordan, Tunisia, and Yemen. Some of these reports were inadequate and have little or no good information on the topics of many sections.

The following topics were suggested for the scope of study which also serves as the terms of reference for the expert:

1. Current water supply and sanitation coverage situation and future needs in the country.

2. Essential features of the technologies/methods employed in supplying water and disposal of excreta/wastewater in rural and peri-urban areas of the country, with successful and unsuccessful applications of these technologies. Suitability of the technologies used, to the national needs and requirements.
3. Needs and requirements for operation and maintenance in water supply and excreta disposal systems serving rural and peri-urban communities.
4. Institutional set up in the country for providing water supply and sanitation services to the rural communities. Agencies and institutions responsible for these services.
5. Environmental Health (EH) institutions capabilities and their strengthening needs in meeting the "Health for All goals (HFA 2000)".
6. Extent of inter-agency collaboration (IAC) in offering water supply and sanitation services to the rural sector in the country. Success of IAC integrating these services with hygiene education for improving the public health.
7. Extent of participation of the communities in all stages of execution and operation of rural water supply and sanitation projects in the country.
8. Human Resources Development and Community awareness strategies and programmes.
9. Suggestions, Recommendations and National Action Plan.
10. An annotated bibliography of country publications (reports, articles, books/ booklets) on the subject.

1. Current Water Supply and Sanitation

1.1 Background

Total area of Iran is about 1.648 million square kilometers (sq. km). The population of Iran, as of 1994 census, is estimated to be 60 million. The population was 34 and 50 millions for the years 1976 and 1986 respectively. Density of population varies from 5 to 291 with an average of 35 persons per sq. km. Over all life expectancy at birth is 67.

Jordan occupies an area of approximately 90,000 sq. km. The total area is divided into the following zones: 71.5% desert, 22.3% arid, 2.2% marginal, 3.3% semi-arid, and 0.7% semi-humid.

The census of 1979 estimated Jordan's population at 2.147 million distributed among 1017 population centers, and growing at a rate of 3.7%. In 1991, Jordan's population was estimated at approximately 3.888 millions and growth rate at 3.4%. The urban/rural population was divided at approximately 77.9% / 22.1% and the estimated nomadic population was about 7,000.

2. Technologies and Methods for water and Sanitation

2.1 Technologies and Methods in Iran

2.1.1 Water Supply

Many of less-populated villages lacking water resources enough to economically justify establishing water pipe-line networks, necessary water supply is supplied from available sources, such as shallow wells, surface water and rainfall.

Rainfall serves as the most common water source in southern Iran, like provinces of Hormozgan, Booshehr, Fars etc. which have little rain through year. In this method, at the time of heavy showers which diverted from limited basins into ground reservoirs accommodating from 50 to thousands of cubic meters inside. These reservoirs have a dome shaped ceiling with trap doors for both ventilation and drawing water out. When sedimentation is completed, the initially turbid water becomes drinkable. The sweetness and low hardness of rain-water is such a great blessing that villagers are unwilling to find any other substitute.

To improve quality of the water as such, periodic chlorination of cisterns is the only treatment applied. Where population happens to protest against the chlorination, people are instructed how to let the water boiled and cooled before use. Other measures usually taken in this respect consist of, protecting flood beds onto cisterns, putting strainers in the way, creating sand-beds before opening of the reservoirs and installing hand pumps for water-drawing. Where water of cisterns is stored in open-reservoirs at ground level (locally called "Hootak"), like in Chah-Bahar in Balouchestan and or Bashagard in Hormozgan, water is purified either by filtration, or by getting passed through sand-filters, or cloth-filters or by chlorination or letting it boiled and cooled; due instructions are continually furnished, by community health workers (CHWs).

As the cisterns (Berkeh) among the most important sources for water supply in rural areas of southern Iran in which less-populated settlements are remotely scattered, betterment and structural modifications in them has appeared in the agenda of water-source betterment schedule since long. A number of new plans for cistern-chlorination were proposed and are under consideration. In the proposed method a shaft must be dug with the same depth as the basin next to it for diverting the water by a pipe laying one meter higher than the bottom of cistern onto the shaft and chlorinated by a submerged pat chlorinating system.

Plain sedimentation of river-waters and chlorination afterwards is another common method in rural areas including Khuzistan and Loristan. Besides, Lime, Ferric Chloride or Aluminum sulphate are applied for adjusting pH wherever possible to keep an appropriate management for maintenance and exploitation.

The CHWs, primarily introduce and educate chlorination by solution with a concentration fit for the water in question and close check over residual chlorine, also teach villages how to let drinking water be boiled and cooled in the places where superficial water or likely polluted shallow sources are used. This method is also followed in the suburbs far from urban and safe sources. Carrying safe drinking water from sanitary protected sources of water to the scattered villages by mobile tankers is one of the means of

rural water supply. Lots of villages also are benefited from community or individual protected sources of water, like springs and shallow wells. The General Department of Environmental Health in the Ministry of Health and Medical education is responsible in this respect.

2.1.2 Sanitary Disposal of Excreta, Sewage and Surface Waters

Common methods in Iran for disposing excreta is to dig absorptive well where ground is penetrable, to build a cabin directly over the well, direct and indirect (by subterranean siphon where water is sufficiently available) disposal in rural areas, erecting a cabin with subterranean siphon in building, connecting ventilation channel to sewage ventilation system as well as diverting wastewater either into the absorptive well or out of the building.

In rural areas and small communities where underground water level is fairly high, Aqua privy are often in use. However, as there is no enough land especially in the North to soak wastewater, shallow underground water is exposed to pollution; therefore villages are instructed to chlorinate and boil water before drinking.

Where ground is rocky and impenetrable, water supply and sanitary disposal of wastes appear among major problem. Such troublesome ground in mountainous and cold areas lacking simple filtration systems like lagoons. High cost of filtration system, maintenance and utilization hinder developing and executing projects of collection and filtration systems. However new approaches tend to employ suitable filtration systems like lagoons are currently under way. Toilet in some areas, are not constructed properly.

Now, projects are extensively followed to divert superficial water flowing on roads or from taps into brooks flowing out of villages. In the areas with highly absorptive ground, absorptive wells are largely dug. Ministry of Health and Medical education is responsible for sanitation activities in rural areas.

2.2 Appropriate Water and Sanitation Technology in Jordan

2.2.1 General Requirements

The data in Table 11 present a summary of some of the general elements and requirements for a proper water supply and sanitation program. The elements include: research and development, health education and community awareness, planning, institutional set-up, building technical capabilities and training, and economic considerations. The chapter presents a summary of the selected water and wastewater systems. More details can be found in numerous available references. The major features of the selected technologies and their applicability in Jordan are presented below. The World Bank publications on Appropriate Water Supply and Sanitations, reflecting the results of research and parallel activities in the field of low-cost water supply and sanitation, were used to develop a significant portion of the on-site sanitation methods, presented in the following discussion.

Table - 11: Requirements of Water and Sanitation Programs (Jordan)
[Table-14, (3)]

Category	Additional Needs	Concerned Organizations	Major Recommendations
Research & Development	<ul style="list-style-type: none"> -Development of Appropriate Technology -Modifications on Existing Technologies for Local Applications -Strengthen R&D departments and cooperation among concerned organizations -Integrate R&D in long term planning 	<ul style="list-style-type: none"> -Universities, -The Water Authority -Royal Scient. Society -Higher Council For Science and Techn. -Ministry of Health -Ministry of Municipalities, Rural Affairs and Environment -International Organizations (WHO), World Bank, others Ministry of Planning 	<ul style="list-style-type: none"> -Specific programs directed towards rural sanitation Management -Improve R&D organizs. cooperation -Educate on importance of all R&D phases including basic research, applied research, Techn. Transfer, & others -Allow Funding for all R&D phases -Provide appropriate Research incentive -Integrate R&D into long term national planning -Encourage R&D as a national policy
General Health Education and Primary Health Care	<ul style="list-style-type: none"> -Adequate staffing and training -Proper Institutional Organization -Proper Monitoring and Inspection programs -Proper Primary Health Care Programs 	<ul style="list-style-type: none"> -Ministry of Health -Private Groups -International Organizations, WHO, UNISCO -Medical and Environ. Health staff at Public Universities -Public and private Media (Radio, Newspapers, TV) 	<ul style="list-style-type: none"> -Improve staffing and training on rural water and sanitation -Train and involve school teachers and provide proper incentives -Improve institutional organization
Planning	<ul style="list-style-type: none"> -Specific Rural Sanitation Programs -Selection of Appropriate Sanitation Techn. -Planning Appropriate Sanitation Upgrading Sequence in Conjunction with Water Services -Formal Community Involvement Programs -Integration of R&D in long term planning 	<ul style="list-style-type: none"> -The Water Authority -Ministry of Health -Ministry of Planning -R&D Institutions -International Organizations, WHO, World Bank -Ministry of Municipalities, Rural Affairs, and Environment 	<ul style="list-style-type: none"> -Establish specific rural sanitation programs -establish specialized rural water and sanitation groups and training programs in The Water Authority Central and Governate Offices -Integrate R&D into rural water and sanitation plans -Set goals and targets for Rural Water and sanitation Programs
Institutional	<ul style="list-style-type: none"> -Specific rural sanitation groups in The Water Authority and/or Ministry of Municipalities, Rural Affairs, and Environment with Adequate staffing, training, Administrative Independence and Adequate Resources 	<ul style="list-style-type: none"> -The Water Authority -Ministry of Health -Ministry of municipalities, Rural Affairs, and Environment -Local Municipalities and Village Councils 	<ul style="list-style-type: none"> -Identify needs, set targets & coordinate responsibilities -Identify and coordinate resources -Establish, based on the above, specialized rural sanitation groups in The Water Authority and/or Ministry of Municipalities, Rural

Table-11, (Cont'd)

	<ul style="list-style-type: none"> -Proper Coordination Among all Involved Parties Including Local Village Councils -Formal Community Involvement 		<ul style="list-style-type: none"> Affairs, and Environment with Adequate staffing, training, Administrative Independence and Adequate Resources -Establish formal Community participation Mechanisms
Economic	<ul style="list-style-type: none"> -Low cost Technolgy -Self Help rural Techn. -low maintenance Techn. -Easily Upgraded Techn. -Maximum Utilization of local resources 	<ul style="list-style-type: none"> -Government Agencies -Citizens of Jordan -International Aid Organizations 	<ul style="list-style-type: none"> -Establish specific rural water and sanitation programs and long term sustainable development plans and strategies
Technical	<ul style="list-style-type: none"> -Trained technical Staff -Training Institutions -Research and Development Institutions -Local Standards and design criteria 	<ul style="list-style-type: none"> -R&D Organizations -Locally Available Public and Private Resources and capabilities 	<ul style="list-style-type: none"> -Asses locally developed & tested Sanitation methods -Develop local sanitation design data and standards -Encourage and involve R&D organizations -Use locally available skilled labor, and materials and provide proper incentives

2.2.2 Treatment of Water Supplies

Chlorinated public water supplies from groundwater wells or fresh water springs are typically pumped directly into the distribution network and/or storage tanks. Chlorine gas or hypochlorite solutions are typically used for disinfection. Most of Jordan's public water supply is from groundwater sources and treatment consists mainly of chlorination. The conventional surface water treatment plant in the town of Zai, located north west of Amman, receives screened and pre-settled water pumped from King Abdullah irrigation canal in the Jordan Valley. The plant, with maximum capacity of approximately 0.125 MCM/d, operates at less than design capacity depending on water source constraints. The plant supplies approximately 15% of the total municipal water supply in Jordan. Treatment consists of two trains of the following in-series treatment processes: screening at source, pre-sedimentation, oxidation using permanganates, coagulation, flocculation, sedimentation, filtration, and chlorination. Powdered activated carbon is also available at the plant and is used as needed. Treated water is stored and pumped to a larger storage tank for distribution by gravity to the capital city, Amman. The other water treatment plant in the city of Irbid has a capacity of 0.02 MCM/d and consists of aeration, coagulation, filtration, and chlorination facilities.

One major problem facing Zai complex treatment plant is related to the quality of water supply from the source, which is subjected to a variety of contaminating sources. In addition, Zai water treatment plant faces operation and maintenance difficulties resulting from the need for sophisticated spare parts and specialized chemicals from abroad, delays in repairs, and timely response to influent water quality changes. It is a local observation that operation and maintenance of sophisticated treatment facilities do not match the needs to achieve full treatment benefits.

Water supply sources from spring and stream water, and rain water harvesting, are also used to a small extent in remote areas by Beduins, farmers, and rural and urban fringe areas. Such waters typically don't receive any treatment and are directly used for potable purposes, thus increasing the risk of infection/disease. The availability of safe water at reasonable cost and convenience alone is not expected to significantly reduce the use of untreated water for potable purposes. Health education and community involvement are necessary to minimize such practices.

2.2.3 Water Treatment Alternatives

Uncontaminated ground waters are generally the most reliable and important source of water supply in Jordan. Uncontaminated ground water requires little or no treatment. Applicable treatment unit processes include aeration, filtration, chlorination, and generally optional removal of hardness. Alternative water sources are generally required when the water is brackish, contaminated, or has high fluoride content. Desalination of brackish and sea water is an option that is under consideration in Jordan because of the scarcity of the resources. The data in Table 12 present a summary of existing and applicable water treatment options in Jordan.

Uncontaminated fresh spring water may not require any treatment if proper water quality is confirmed and monitored. Chlorination of uncontaminated fresh spring water is generally recommended, to ensure the presence of residual chlorine in the distribution system, to protect against any possible contamination through the distribution network. In general individual household water treatment systems are not suitable for drinking purposes, especially with the current availability of safe and public water supplies in all parts of the country. However, house hold rain harvesting systems should be encouraged, especially, in rural areas, to be used for purposes other than drinking, to reduce the cost of consumed water and conserve resources.

There are many applicable drinking water treatment processes. A summary is presented in Table 13. The appropriate combinations of such processes are presented in the following sections.

Table - 12: Alternative Drinking Water Treatment Processes (Jordan)
[Table-16, (3)]

	Surface Water Treatment	Ground Water Treatment
Household Systems	-No Treatment (High Health Risks). Including personal and contracted drinking water supplies from unconfirmed-quality water springs, streams, and water reservoirs.	-No Treatment (High Health Risks). Hand and motor pumps are preferable to bucket and rope -Household package treatment methods are expensive and generally unreliable
Public Systems	-No Treatment/Storage/ Distribution. Requires proper water quality confirmation and continuous monitoring. Not recommended due to possible contamination in the distribution networks. -Straining/Chlorination/Storage/ Distribution. For high quality surface water sources to remove floating solids. -Screening/Slow Sand filtration /Storage/ Distribution. Remove solids including biological and turbidity. Used for acceptable uncontaminated high quality water sources and for small communities. -Conventional Water Treatment. For general quality water streams and reservoirs receiving typical waste discharges. Conventional Treatment generally involves: Screening; pre-sedimentation; oxidation; coagulation/flocculation; Sedimentation; Filtration, Chlorination; storage; and Distribution. -Directly Contaminated Water. Use alternative water sources	-No Treatment/Storage/ Distribution. Requires proper water quality confirmation and continuous monitoring. Not recommended due to possible contamination in the distribution networks. -Chlorination/Storage/ Distribution. Most common in Jordan. Appropriate water quality requires confirmation and continuous monitoring. -Aeration/Filtration/Storage/ Distribution. Necessary to treat reduced species. -Desalination of Brackish water (See Below) -Contaminated Ground Water. Use Alternative Water Sources depending on contamination.

Table - 13: Selected Pollutant Treatment Alternative (Jordan)
[Table-15, (3)]

Treatment Process \ Water Pollutant	Screening	Oxidation/Reduction	Precedimentation	Coagulation/Flocculation	Sedimentation	Filtration	Chlorination	Aeration	Softening	Adsorption	Reverse Osmosis	Precipitation	Ion Exchange
Large Objects/Solids	x												
Suspended Solids			x	x+	x	x							
Pathogenic Bacteria			x	x+	x	x	x			x			
Fluoride				x+						x		x+	x
Turbidity				x+									
Humic Acids		x		x+						x			
Total Dissolved Solids											x		
Iron and Manganese		x											
Nitrate											x		x
Chloroform								x		x	x		
Hardness									x+		x		x
Oxygen								x					
Carbon dioxide								x					
Taste & Odor (1)		x		x+			x	x		x			
Color		x		x+			x			x			

x+ = requires further solid-liquid separation step

(1) = Control at the source is a viable option (i.e., algae control)

2.2.4 Wastewater Treatment

Collected wastewater is treated mainly in stabilization ponds, but other wastewater treatment systems are also used including activated sludge, oxidation ditch, rotating biological contactors, and trickling filters.

According to the data presented in Table 11, and based on initial design capacity, approximately 75.1% of the collected sewage is treated in stabilization ponds, 18.1% in trickling filter Wastewater Treatment Plants (WWTPs), and 6.8% in activated sludge WWTPs. Currently, the original design capacities of the major WWTPs are exceeded and upgrading projects are underway or being planned. The influent to As-Samra WWTP, the largest in the country, increased from approximately 50,000 m³/d in 1985 to approximately 125,000 m³/d at the present time, mainly due to the increase in the number of consumers connected to the WWTP. Information regarding the existing WWTPs, selected effluent quality parameters, type of treatment, and point of discharge is presented in Table 14 and 15. Even though most of Jordan's WWTPs started operations after 1985, they generally suffer from many difficulties including: improper design and selection of technologies, lack of proper preconstruction impact assessment and proper public participation in planning, inadequate operations and lack of preventive maintenance, aesthetic problems, financial problems, and other difficulties. A summary of other related difficulties is presented in Table 16.

Table - 14: Jordan's Municipal WWTPs and Effluent Quality
[Table-11, (3)]

WWTP Name/ Location	Design Capacity	Effl. BOD5	Effl. TSS	Effl. NH3	Effl. NO3	Effl. TDS	Fecal Clfrm
AS-Samra	68,000	104	175	103	1.8	1160	3864
Ramtha	2335	154	963	119	3.3	1156	1500
Irbid	11000	43	43	68	35	1007	98480
Kofranja	1800	34	46	30	110	974	3198
Mafraq	1800	220	224	142	1.6	1068	28840
Jerash	1155	13	27	33	4.2	790	601
Baca'a	6000	115	98	113	0.93	1075	38330
Abu-Nussier	4000	15	57	4.6	221	900	222
Salt	2440	14	24	3.1	40	763	262
Madaba	2000	83	293	125	1.1	1221	25201
Kerak	786	57	78	47	6.3	837	302
Tafila	800	49	44	65	5.5	806	1272
Ma'an	1330	72	103	68	1.6	1312	5228
Aqaba	9000	50	80	10	0.9	959	103
Ain-Ghazal*	60000	--	--	--	--	--	--

*-Abandoned 1985

Table - 15: Type of Treatment and Effluent Discharge (Jordan)
[Table-12, (3)]

WWTP Name/Location	Type of Treatment	Start of Operations	Point of Effluent Discharge
AS-Samra	Stabilization Ponds	1985	Surface Water
Ramtha	Stabilization Ponds	1987	Local Irrigation
Mafrad	Stabilization Ponds	1987	Local Irrigation
Maqaba	Stabilization Ponds	1988	Local Irrigation
Ma'an	Stabilization Ponds	1988	Local Irrigation
Aqaba	Stabilization Ponds	1987	G. Injection/Irrig.
Irbid	Trickling Filters- Activated Sludge	1987	Surface Water
Kofranja	Trickling Filters	1988	Surface Water
Baq'a	Trickling Filters	1988	Surface Water
Kerak	Trickling Filters	1988	Surface Water
Tatifa	Trickling Filter	1988	Surface Water
Jerash	Oxidation Ditch	1983	Surface Water
Abu-Nussier	RBCs, Oxidation Ditch	1988	Surface Water
Salt	Activated Sludge/Mechanical Aeration	1981	Surface Water
Ain-Ghazal*	Activated sludge	1968	As-Samra WWTP

*Abandoned 1985

Table - 16: Major Problems Associated with Jordan's Sewerage Systems.
[Table-13, (3)]

Identified Problem	Major Causes and Effects
Sewer Problems	Solid deposits in pipes and manholes; High storm water inflow; Odors and potential corrosion problems
Overloading (Organic and Hydraulic)	Expansion of collection networks; Storm water inflow; Improper design; Addition of night-soil
High Operating Costs Leading To Unit Shut-Downs	Use of Improper Technology; Improper operation and control; lack of timely maintenance; Spare parts not available locally.
Improper Effluent Quality	Overloading; Operation and maintenance problems; Improper design; Uncontrolled disposal of inhibitory and difficult to treat industrial wastes
Pathogenic Health Risks	Inadequate disinfection; Improper removal of helminths by WWTP; Possible direct human use and contact; Contamination of water sources; Fly and mosquito breeding
Odor Problems	Overloading; Inadequate operation and maintenance; Close to residences; Need for desludging; Expensive to control; Failure to involve the community
Operation and Maintenance	Inadequate staffing and training; Improper Design; Improper technology; Improper maintenance; Operation skills don't match technology requirements; Delays in maintenance; Improper response to variable conditions in timely manner; Ineffective preventive maintenance..
Sludge Handling Problems	Insufficient Planning, Research and Development; Presence of Pathogens and possibly heavy metals

2.2.5 The Need For Local Design Criteria

Per capita water consumption in Jordan is significantly lower than that in industrialized countries. Consequently, wastewater constituents are more concentrated than those measured in industrialized countries sewage. The addition of septage to wastewater treatment plants further increase the concentrations of contaminants in the wastewater. Even weak strength wastewaters in Jordan may exceed in concentration strong wastewater of the industrialized nations. For example, the BOD and TSS concentrations in high strength wastewater in the U.S are approximately 400 mg/L and 350 mg/L, respectively, while the average of both BOD and TSS concentrations in Jordan may exceed 1000 mg/L. Most of the available sanitation works design data are based on wastewater characteristics of industrialized countries, which may not be appropriate for Jordan. In Jordan, high concentration of wastewater solids, wide use of pour-flush toilets rather than cistern-flush toilets in conjunction with sewers, and low per capita water consumption, combined with less sophisticated pipe manufacturing and sewer construction techniques, require design criteria different than those used in the United States and other industrialized countries. Similarly, little design data are available for the design of wastewater treatment facilities that take into account the nature of locally produced wastewater. High strength wastewaters generally require longer detention periods in conventional biological treatment processes. Treatment of concentrated wastewaters may requires more than one biological treatment step, or may require significant effluent recycling to dilute the influent, or both actions.

2.2.6 Sanitations Methods

Sanitation methods are divided into two major groups depending on the point of waste disposal:

- 1- On-site disposal methods, and
- 2- Off-site disposal.

Generated household wastes include either excreta and minor cleaning and flushing water, or all household wastewater including excreta. A simple classification of selected disposal methods is presented in Table 17.

Table - 17: Selected Sanitation Methods (Jordan)
[Table-18, (3)]

	On-Site Disposal Methods	Off-Site Disposal Methods
Excreta Only	Pit Latrines; Ventilated Improved Pit Latrines; Pour-Flush Toilets; Composting Toilets; Aquaprivies.	Vaults
Household Wastewater	Septic Tanks	Conventional Sewerage; Sewered PF toilets, Sewered Septic Tanks, Sewered Aquaprivies.

In selecting appropriate sanitation methods, the following local factors were considered:

- 1- Approximately, 60% of Jordan's population is connected to wastewater collection networks, mostly in urban areas;
- 2- Most of the population, urban and rural, have access to potable water through house connections;
- 3- Water resources are limited and water conserving, least polluting sanitation methods are preferable;
- 4- Most of the population not served with public sewerage system use pour flush toilets in conjunction with cesspits or septic tanks;
- 5- A significant portion, estimated at 26%, of rural areas lack appropriate sanitation methods;
- 6- Water is typically used for anal cleansing;
- 7- Methods with the least direct contact between users and fresh or digested excreta are favorable;
- 8- Methods that require committed user attention to maintain health benefits and aesthetics are not socially practical;
- 9- Methods that provide maximum privacy in and around the latrine are favorable;
- 10- Water services expansion was not accompanied with similar sanitation expansion. Accordingly, present sanitation systems may require upgrading during a transitional period; and
- 11- Ground water table is generally deep in Jordan.

According to the above criteria, the following sanitation methods are identified, Table 18. A discussion of the essential features of each identified selection is presented below.

The institutional set-up for urban water supply and sanitation is well established. In-house water supply and wastewater collection services for urban consumers are provided by The Water Authority of Jordan. Rural Sanitation requirements, however are not clearly defined as part of an established and organized institutional responsibility. The data in Table 19 show the rural sanitation needs and requirements.

Table - 18: Selected Sanitation Technologies (Jordan)
[Table-19, (3)]

	Tanker Water and Hand Carried Water Supplies	Tanker Water and Household Water Supply	Common System water. Supply through House connections
High and Medium Density Urban Areas	-N/A	-N/A	-Sewerage
Low Density Urban Areas	-N/A	-PF toilets	-Vaults* -Septic Tanks -Sewerage**
Rural Areas	-PF Toilets	-PF Toilets -Vaults*	-PF Toilets -Vaults* -Septic Tanks
Temporary Settlement	-PL	-N/A	-N/A

*=Overloaded and clogged pits require emptying using vacuum tankers

**=Construction of sewerage system is being extended to almost all urban areas

Table - 19: Rural Sanitation Institutional Requirements (Jordan)
[Table-20, (3)]

Areas of	Who is doing it, and who should be involved
Setting construction Standards and Design Criteria	Ministry of Municipalities, Rural Affairs, and Environment; Experienced builders, Civil Engineers, Ministry of Public Works
Enforcing and Assessing Building Standards	Inspectors of municipalities and local village councils, Engineers Association
Providing Credit/Financial Assistance	Municipalities and local village councils, private institutions, Ministry of Health, The Water Authority, Ministry of Municipalities, Rural Affairs, and Environment
Ensuring proper use, maintenance, and disposal of pits and tanks contents	Health Inspectors of Municipalities, local village councils, and health institutions; education and awareness programs by Ministry of health personnel, private and international groups
Assist in redigging and emptying pits and tanks night soil	Municipality and local village councils, private Firms
Assist and monitors Disposal of pits and Tanks night-soil Contents	Municipalities and local Village Councils, The water Authority
Monitors Sanitation Impacts on the Environment	The Water Authority, Ministry of Health, Health inspectors of Municipalities and village councils, R&D organizations, Ministry of Municipalities, Rural Affairs, and Environment.

2.2.6.1 On-Site Sanitation Technologies

In this section, a brief discussion of pit latrines, ventilated and improved pit latrines, pour-flush toilets, and septic tanks is presented. Other on-site excreta disposal methods such as composting toilets are not discussed and generally considered technically and socially inappropriate for individual Jordanian households.

1. Pit Latrines

Pit latrines, Figure 1, consist basically of a hole in the ground into which excreta falls, a squatting plate covering the hole, and a ventilated outdoors superstructure. Once the hole nearly full, it is typically filled with soil and a new one is dug nearby

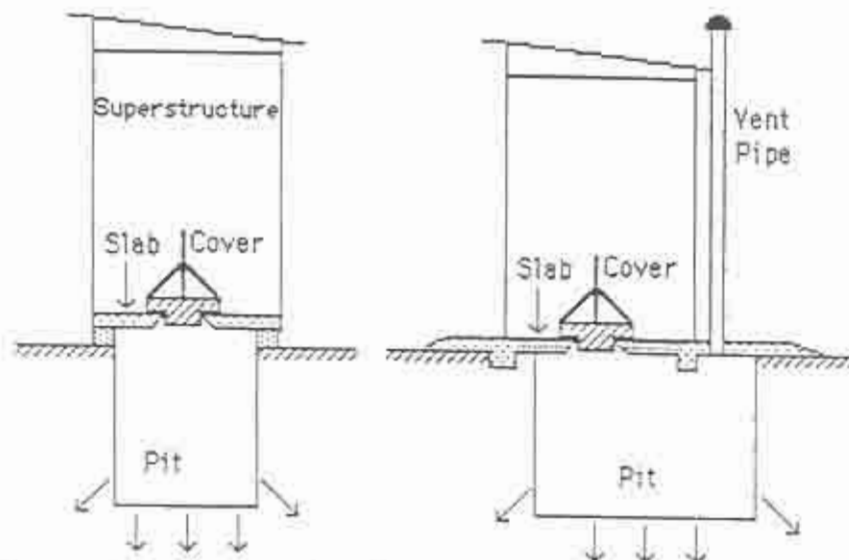


Figure 1. Conventional and ventilated pit latrines.

The main disadvantages of pit latrines are: smell, and breeding of flies and mosquitoes. Because of the disadvantages associated with pit latrines, they are not recommended for sanitary applications.

However, a minor portion of the population occupies outdoors seasonal settlement that is close to residential areas, thus making outdoor sanitation practices unavailable. For such people, frequently replaced pit latrines built using simple materials may be appropriate. Otherwise, existing pit latrines need to be upgraded.

2. Ventilating Improved Pit Latrines (VIPs)

VIPs avoid the major disadvantages of conventional pit latrines by providing an external vent pipe through which, air circulates down the opening in the squatting plate and up the vent pipe. VIPs are odorless and have minimal mosquitoes and flies breeding problem. An alternating double-pit latrine can be used to avoid deep, single pit excavation.

VIPs may be considered as an alternative in upgrading existing pit latrines. VIPs are generally suitable, especially for low to medium density rural areas, where most residences are single-storied, and where the members of the same family share the unit. In Jordan, and since such units require separate outdoor structure, proper privacy should be maintained in and around the unit. It is important to have access to emptying the unit and digging a replacement pit. VIPs are not designed to receive household wastewater other than excreta and squatting plate cleaning water, and accordingly are inappropriate where in-house water is available. VIPs have the following characteristics:

- 1) ease of construction and maintenance;
- 2) low annual and construction costs;
- 3) all types of anal cleansing material can be used;
- 4) absence of odors, and minimum fly and mosquito breeding;
- 5) minimal water requirements;
- 6) low level municipal involvement and high self help potential;
- 7) minimum risks to health;
- 8) good potential for upgrading to pour-flush toilets; and
- 9) stable permeable soil is required.

However, if improperly designed and used, pit latrines may pollute ground water. In addition, and unless double pits are used pit latrines require replacement when full, and accumulated sillage requires proper disposal arrangements.

3. Pour-Flush Toilets (PF)

Pour flush toilets, Figure 2, use a squatting plate with a water seal to prevent odors and mosquito breeding. The pit used in injection with pour flush toilet is typically offset, and the PF bowl is connected to the pit by a sloping pipe. Water, approximately 1 to 2, liters is used to flush the excreta down the tube into the pit. PF toilets can be constructed inside or outside the house. An alternating double-pit can be used to avoid deep, single pit excavation, and future need to dig a replacement pit.

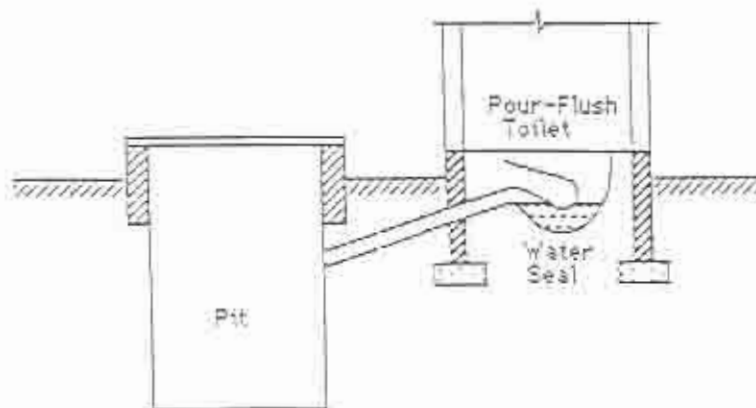


Figure 2. Pour-flush Toilet.

PF toilets, in conjunction with seepage pits, are not designed to receive household wastewater other than excreta and flushing water, and accordingly are expensive to operate where in-house water is provided and generated wastewater is discharged to the pit. PF bowls are widely used in Jordan, in conjunction with on-site or off-site disposal methods. The use of PF bowl is appropriate in Jordan because water is typically used for anal cleansing and the water requirements are low. PF toilets have the following characteristics:

- 1) possible location within the house, thus providing convenience and privacy;
- 2) no odor and fly or mosquito breeding;
- 3) minimal risks to health;
- 4) low level of municipal involvement;
- 5) low annual and construction costs;
- 6) ease of construction and maintenance;
- 7) high potential for upgrading; and
- 8) suitable for rural and low density urban areas.

Septic Tanks

Septic tanks, Figure 3, are below-ground sealed concrete chambers designed to receive all house hold wastewater, including excreta and flushing water. In the tank, solids settle to the bottom where they are anaerobically digested, scum rises to the surface, and a relatively clear water remains in the middle. Settled wastewater is withdrawn from the middle section of the tank and disposed off in a following drain field or soak away unit. Septic tanks are designed to have one or two compartments, with the two compartment preferred because the effluent TSS is lower. Adequate retention time is provided to ensure proper settling of the solids and storage of the sludge. The tank requires dislodging once it becomes full.

Septic tanks are appropriate for low density urban areas supplied with in-house water connections. They generally require large space, high degree of user's attention, and have a relatively high cost. Their main advantage is that they are convenient for household waste disposal requirements.

Septic tanks have the following characteristics:

- 1) high and operating construction costs;
- 2) requires skilled labor for construction;
- 3) low potential for self help;
- 4) require permeable soils;
- 5) require off-site facilities for disposal of accumulated sludge;
- 6) good health benefits;
- 7) requires low municipal involvement;
- 8) appropriate for houses with in-house water and sufficient land for tank effluent disposal (i.e., low density urban areas); and
- 9) can easily be connected to public sewerage system.

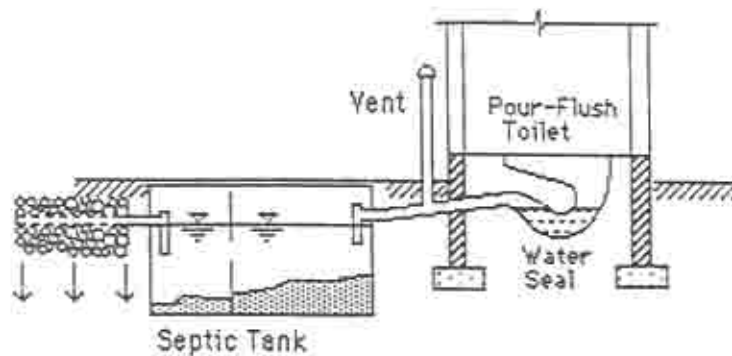


Figure 3. Septic tank using drain field.

2.2.6.2 Off-Site Sanitation Systems

Three off-site wastewater disposal methods are discussed briefly in the following sections: vaults, small-bore sewers, and conventional sewerage systems. Conventional sewerage systems are currently widely used in Jordan's urban areas, covering approximately 60% of the total population.

1. Vault Toilets

Vault toilets, Figure 4, are not generally considered suitable for Jordan's rural areas, mainly because they require frequent, and expensive emptying compared with seepage pits. In addition, improperly designed and constructed seepage pits require frequent emptying especially if the soil is impermeable, the pit becomes clogged, and water supply using house connections contributes to increasing wastewater generation. Vault toilets are similar to PF toilets except that the pit is a sealed one.

With increasing water consumption in rural areas and until sanitation services catch-up with water services, there remains a need to operate a low cost and dependable collection vehicle system by responsible agencies. The system requires appropriate disposal sites for household generated wastes, and municipalities assistance and monitoring. It is important to monitor such systems especially for illegal disposal by tanker operators, especially when private firms are contracted to do the job.

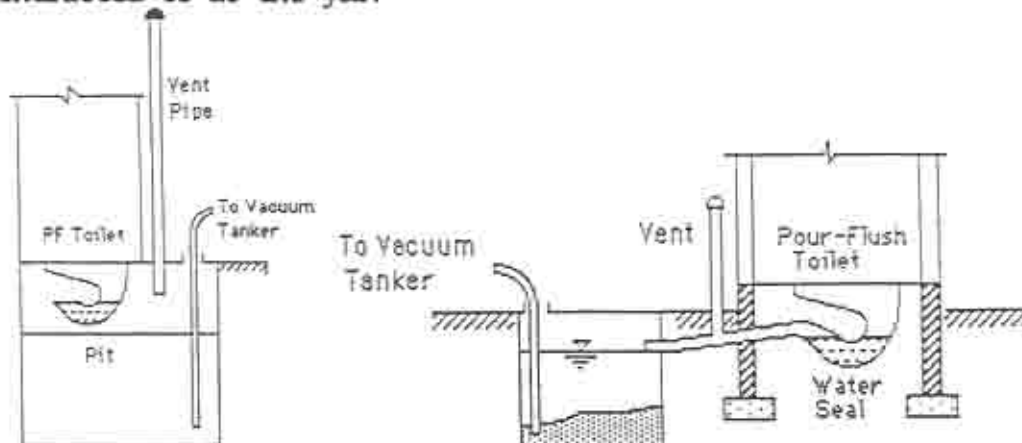


Figure 4. Pour-flush vault toilet systems.

2. Small-Bore Sewers

Small-bore sewer systems are designed to transport the liquid portion of residential wastewater. The solid part of the waste is removed in residential intercepting tanks, Figure 5, which have to be dislodged regularly.

Small-bore sewer systems can be considered as the last step in a sanitation sequence and are considered a reasonable upgrading step when on-site disposal methods are no longer feasible due to increased water consumption resulting from the introduction of water services through connections and increased population density in the area.

Small-bore sewers are less expensive than conventional sewerage mainly because of reduced pipe size, fewer manholes needed, shallower excavation required, flatter slopes, and reduced maintenance requirements. However, such system require the continuous operation of on-site septic tanks including dislodging and disposal. In real life applications, the use of small-bore size sewerage systems in comparison with conventional sewerage is limited.

Sewage collection is not technically appropriate for areas without in-house water services, and expensive for areas with low residential density. Small-bore sewer systems have high construction cost and relatively medium operation cost. The system requires skilled engineers and builders and complementary off-site wastewater treatment and sludge disposal and management facilities. The system also requires high level of institutional involvement. Sewage collection, however, offers excellent health benefits when properly functioning.

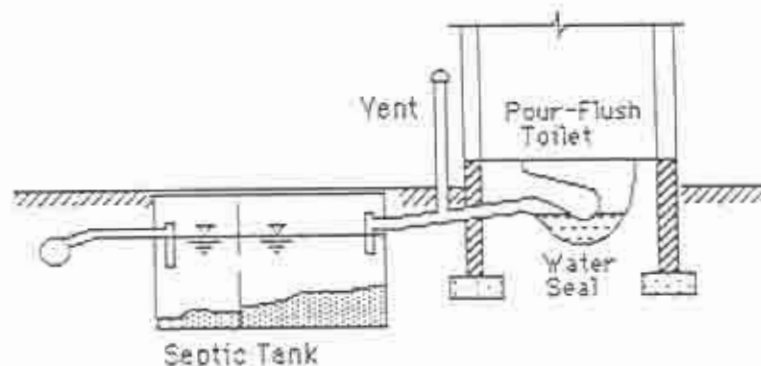


Figure 5. Small-bore sewer system and septic tank installation.

3. Sewerage

Most of Jordan's urban areas and approximately 60% of the population are currently connected to public sewerage systems. Both, cistern-flush and PF bowls are used in conjunction with the sewage collection system. The sewerage system is totally managed by the Water Authority. Fourteen WWTPs, distributed all over Jordan, are currently used to treat the collected sewage. The Water Authority continues to expand the public sewer system and approximately 70% of the population are expected to be connected by the end of the decade.

Sewage collection is not technically appropriate for areas without in-house water services and very expensive for areas with low residential density. Small-bore sewer system has high construction cost and high operation cost. The system requires skilled engineers and builders, and complementary off-site wastewater treatment and sludge disposal and management facilities. Sewerage require high level of institutional involvement. Sewage collection, however, offers excellent health benefits when properly functioning.

In addition to the above discussion characteristics of the various selected sanitation methods, the following, Table 20, is a general evaluation of the above discussed systems.

Table - 20: Evaluation of Selected Sanitation Systems (Jordan)
[Table-21, (3)]

CRITERIA	Pit Latrine	PF Toilet	Vaults	Sewered PF Toilet	Sewerage
Economic Factors					
Investment	VG	M	G	B	VB
Running Expenses	VG	VG	M	M	M
Shadow Price [†]	VG	M	VB	VB	VB
Maintainability					
Durability	VB	G	G	G	G
Operation Skill	VG	G	B	M	VB
Reparation Skill	VG	B	B	B	VB
Spare Parts	VG	G	VB	M	B
Acceptability					
Will to Pay	VG	B	M	B	VB
Sociological	VB	G	M	G	VG
Benefits					
Community Health	M	G	M	VG	G
Development	VB	G	M	VG	VG
User Comfort	VB	G	G	VG	VG
Environmental	M	VG	G	VG	B

VG - Very Good, M - Medium,
G - Good, VB - Very Bad
B - Bad

F - Shadow Price reflects economic price not market price. Market price may be distorted due to factors such as subsidies, taxes, duties, and so on.

2.2.7 Off-Site Domestic Wastewater Treatment

Residential wastewater treatment aims at achieving three main objectives:

- 1- Removal and destruction of pathogens, obviously for health reasons;
- 2- Removal and destruction of organic matter to minimize their polluting impact on receiving water bodies and subsequent water use; and
- 3- Removal of solids to minimize deposition in receiving streams and water impoundments, and the negative impact on subsequent effluent use.

There is a variety of process combinations used to achieve the above goals with variable degree of success. As discussed in the above sections, the present wastewater treatment systems in Jordan can be classified as being either:

- 1- Conventional wastewater treatment technologies, including the use of activated sludge system variations, rotating biological contactors, trickling filters, and process combinations.
- 2- Stabilization ponds, generally referred to in Jordan as natural treatment systems.

2.2.7.1 Conventional Wastewater Treatment

In general, wastewater treatment is achieved in several in-series steps including:

- 1- screening to remove large objects;
- 2- grit removal used to remove relatively large and dense inorganic solid particles such as sand, silt, egg shells, and other particles;
- 3- primary sedimentation which removes most of the suspended solids and a substantial portion of the influent organic solids loading;
- 4- aerobic biological treatment designed to remove and destroy the organic materials in the wastewater. In the process, microorganisms, mainly bacteria, use the organic material in the wastewater as food to build new cells and to provide energy to carry out its functions. Microorganisms are suspended solids in water and thus can be removed by a following sedimentation step. In optimizing the design of such systems, sanitary engineers try to maximize the removal of organic material, operate the system in the range that produce microorganism's with good settling characteristics; and minimize the quantity of produced sludge. There are several methods used to achieve aerobic biological treatment including:
 - a. the activated sludge system and its variations including extended aeration and oxidation ditch systems.
 - b. trickling filters; and
 - c. rotating biological contactors, RBCs.

- 5- final sedimentation step designed to settle the microorganisms produced in the biological treatment step;
- 6- effluent disinfection designed to remove and destroy the pathogenic content of the effluent. Chlorination, which is used extensively in North America, may not be appropriate for Jordan, as discussed in a following section.

The solids that settle in the primary and final sedimentation basins contribute to the total sludge production in the treatment plant. The produced sludge is mainly water, approximately 97%. Sludge treatment aims at reducing the mass and volume of the sludge, improving its handling characteristics, and destroying its pathogenic content. Sludge treatment may involve steps such as:

- 1- Sludge thickening which results in sludge volume reduction due to the separation of some water from the solids by gravity sedimentation. Thickening also improves the operation of following sludge treatment steps.
- 2- Sludge digestion in which the mass of the solids is reduced when the bacteria consumes its own protoplasm for the lack of external food. Digestion results in the destruction of pathogens, depending on the mode of digestion (batch or continuous), the digestion temperature, and the digestion time. Sludge digestion can be achieved either aerobically or anaerobically. Digestion also improves the operation of following sludge dewatering steps, when available. Anaerobic digestion results in the formation of methane, a biogas that can be used as an energy source. Thermophillic composting, discussed below, can be effective in destroying all sludge pathogens.
- 3- Sludge dewatering which aims at further reducing the volume of the sludge through separating the liquid from the solids using squeezing plates, belts, centrifuges, or other methods.
- 4- Sludge drying in drying beds which achieves volume reduction and pathogens destruction, except for helminth ova. Sludge drying beds may receive sludges from any sludge treatment step discussed above.

There are many problems associated with using conventional treatment technologies in **Jordan**, some of which were listed in Table 16, above. The following is a brief discussion of some major difficulties encountered using conventional treatment technologies in Jordan:

- 1- Without chlorination, even if the BOD was reduced to below 20 mg/L, the effluent from conventional WWTPs contains large amounts of bacteria, viruses, protozoa, and helminth ova. The detention time in conventional treatment plants is low, generally less than one day, which explains in part the poor effluent quality in terms of helminths removal.

Even with chlorination, viruses, protozoan cysts, and helminth ova are not properly removed. Large chlorine doses are generally needed to reduce coliforms in the effluent, and even higher doses are needed to achieve incomplete viral removal.

Tertiary treatment is required to improve the removal of pathogens. Effective tertiary treatment include: slow sand filtration, land application, maturation ponds, or chemically assisted sedimentation steps.

- 2- High maintenance and operation costs which resulted in many instances in Jordan in unit shutdowns. Much of the designs and equipment have high foreign exchange costs.
- 3- The operation and maintenance of conventional WWTPs require high level of training and maintenance skills. Long delays in maintenance and the need for foreign spare parts are major disadvantages. In addition, conventional WWTP have high energy requirements.
- 4- Highly concentrated wastes, such as those measured in local wastewaters, require in series treatment steps (i.e., trickling filter followed by activated sludge), large effluent recirculation to dilute the influent, the use of tertiary treatment steps, or other appropriate technologies.

Conventional treatment systems, including appropriate pathogens removal tertiary step, are generally appropriate for high density urban areas with limited land availability and high population. The cost of treatment can be reduced considerably if appropriate sludge management methods are employed, including cost recovery. Conventional treatment however, requires among others: adequate staffing, highly skilled labor, efficient and timely preventive maintenance, specialized and specific hands-on training, and appropriate incentives to attract quality operators.

The sequencing batch activated sludge treatment system is currently gaining wider popularity in the united states for both domestic and industrial applications. The system consists of two or more basins that are used in a sequencing order, and aeration and settling are performed in the same tank. Additional advantages of the system include savings on the land requirements and possible nitrogen control in the effluent. In operating the system, pretreated wastewater is introduced to the active basin(s) and aerated for a predetermined period of time. Aeration is then discontinued and the contents of the basin(s) are then allowed to settle. At the same time, more wastewater is introduced to the other basin(s) for aeration. After settling, the effluent is decanted and discharge. During the settling period, anoxic conditions result in denitrification, thus allowing the control of nitrogen in the effluent. Exoess sludges can be withdrawn from the tank during the idle period. The cycles can be operated manually or automatically. Adopting such a system for smaller local applications requires local modifications and testing.

2.2.7.2 Stabilization Ponds

In general, due to the availability of vast desert land and proper climate conditions, especially in the Badia region of Jordan, waste stabilization ponds are considered economical and appropriate, compared with conventional wastewater treatment system. Waste stabilization ponds are relatively shallow ponds in which organic material is stabilized in a variety of complex reactions involving mostly bacteria and algae, and physico-chemical processes including sedimentation, gas transfer, oxidation-reduction, and other processes. The treatment processes involved

in wastewater stabilization in ponds are much more complex than those in conventional biological systems. Considering the removal of pathogens, properly designed and operated stabilization ponds are the most economical available treatment method. In addition, stabilization ponds require minimum operation and maintenance attention skills and efforts. Stabilization ponds have no mechanical equipment and have low energy requirements.

Although waste stabilization ponds are not generally appropriate for large communities, Jordan operates one of the largest waste stabilization ponds in the world, serving almost one third of the population. An expansion and upgrading of the system, which is currently overloaded, and the addition of new wastewater flows are currently underway. The depth of waste stabilization ponds is limited and accordingly, the higher the wastewater load to the ponds, the higher the required surface area. Evaporation, and consequently the annual loss of needed millions of cubic meters of water, especially during the dry season, is a major problem facing large community waste stabilization ponds. In addition, waste stabilization ponds have moderate efficiency during the wet season, have potential odor, flies, and mosquitoes problems, and can result in ground water contamination.

Three types of ponds are commonly used in series in Jordan (hot climate): anaerobic ponds; facultative ponds; and aerobic maturation ponds. Anaerobic ponds have detention times of 2 to 5 days, depth of 2 to 4 meters, and require dislodging when approximately half-full. In facultative ponds, aerobic, facultative, and anaerobic bacteria stabilize the organic content in the wastewater. Algae, naturally growing at the surface of the pond, provides oxygen to aerobic bacteria in the pond. Facultative ponds have typical detention times of 10 to 30 days and depths of 1 to 1.5 meters. Aerobic maturation ponds are used to polish the effluent of the facultative pond, most importantly, to remove and destroy pathogens, to remove suspended solids, and to achieve further BOD removal. Maturation ponds are designed with detention times of 5 to 10 days and 1 to 1.5 meters depth. A total pond retention time of 20 days or more achieves effluent with low viruses and bacteria, and is almost free of helminths and protozoans .

2.2.7.3 Aerated Lagoons

Aerated lagoons are similar to stabilization ponds in construction, and the process is similar to activated sludge in its function. Surface mechanical aerators are used to supply oxygen necessary for aerobic removal of organic compounds. Aerated lagoons however, can tolerate higher organic loading than stabilization ponds but lower than conventional treatment systems. Accordingly, aerated lagoons require pre-treatment steps to reduce the organic loading to tolerable limits. One possible scheme is to use anaerobic stabilization ponds as a pre-treatment step. Maturation ponds following the aerated lagoon are necessary to settle lagoon solids and reduce the effluent pathogenic content. Jordan is considering upgrading As-Samra waste stabilization ponds system to handle the increased loading. One option that is being considered by the Water Authority of Jordan is to add mechanical aerators in selected ponds in the system.

A general comparison of the above treatment alternatives is presented in Table 21.

Table - 21: Comparison of Wastewater Treatment Alternative (Jordan)
[Table-21, (3)]

Item	Conventional Technologies ^A	Aerated Lagoons ^B	Stabilization Ponds ^C
Construction Cost	RH	RL	RM
Operation Cost	RH	RM	RL
System Efficiency	G	G	G
Pathogens Removal	RL	RH	RH
Area Requirements	RL	RM	H
General Applicability	High density, large urban community	Upgrading existing Ponds system	R. Small Urban Community with Land Availability

A-Including chlorination, B-A system in-series of anaerobic ponds, aerated lagoons, and maturation ponds, C-A system in series of anaerobic ponds, facultative ponds, and maturation ponds. R=Relatively, H=High, M=Medium, L=Low, G=Good given proper operation and maintenance.

2.2.7.4 Land Treatment of Wastewater

Land treatment processes involve the application of pretreated wastewater at the surface of the soil using the available irrigation methods. The controlled land application of wastewater can return valuable nutrients to the soil. There are three typical land treatment methods: (1) slow rate; (2) overland flow; and (3) rapid infiltration. Land treatment can achieve a variety of objectives including:

- 1- producing marketable crops and biomass for human consumption, biogas production from the biomass grown, and other uses;
- 2- groundwater recharge;
- 3- wastewater treatment;
- 4- removal of pathogens, especially using slow rate systems; and
- 5- provide an alternative to effluent discharges to surface waters.

Of the three land treatment process variations, slow rate land treatment is the most widely used method. Rapid infiltration (RI), although can achieve efficient treatment, is typically designed to achieve specific objectives such as groundwater recharge rather than wastewater treatment. The process (RI) involves the application of wastewater to shallow groundwater basins in highly permeable soils in a cyclic loading pattern. Vegetation is not considered in the design of the RI process. RI achieves limited nitrogen removals and may result in negative impacts on the quality of groundwater.

Overland flow land treatment (OF) involves the application of treated wastewater to carefully prepared vegetated sloped soil surfaces and collecting the excess runoff in collection ditches to be discharged to surface waters. The process is suited for impermeable soils. The system is not as effective in removing pathogens as the slow rate method.

However, in developing countries, excreta-related diseases are rather common as wastewater contains high concentrations of excreted pathogens (viruses, bacteria, protozoa and helminths) that cause disease in man. As wastewater is used in agriculture for the production of agricultural crops intended for human consumption, it poses consumer and workers risks. Therefore, the health aspects of wastewater reuse should be emphasized and WHO and governmental guidelines should be followed carefully.

1. Slow rate Land treatment

Slow rate land treatment is practiced in many parts of the world. In the process, wastewater treatment is achieved naturally through the controlled and intermittent application of wastewater to soils and crops. Prior to application, wastewater must receive minimum treatment depending on the intended reuse of the water. To protect human health, a minimum primary treatment is required for irrigation in isolated locations with restricted public access, and is limited to crops not for direct consumption. When used for human food not to be eaten raw and irrigation in public access areas, the wastewater must be treated in secondary facilities and proper pathogens removal must be achieved prior to application. Pre-application treatment is also required to prevent odor formation, meet distribution system constraints, remove excess ammonia, meet crop requirements, protect equipment, and reduce costs for operations and maintenance.

The rate of wastewater application to land depends on whether irrigation is intended for percolation and meeting crop demands or meeting crop demands only. Wastewater is applied intermittently to allow the aerobic restoration of the active upper soil zone. During the rainy season, application of wastewater is interrupted, unless irrigation is used for forested areas. In addition, wastewater application is connected to the plants growth periods.

A variety of important design considerations should be evaluated prior to the successful application of the technology. Site characteristics considerations include soil type, depth, hydraulic characteristics, groundwater depth, ground slope, and land use. Climate considerations are important to determining proper selection of crops, storage requirements, crop water requirements, evapotranspiration, and amount of precipitation.

The performance of the system has been demonstrated at many locations world wide. BOD removals exceeding 99% have been achieved in the United States when the application rates were in the range 3 to 10 kg/ha-d. Similarly, the process achieved efficient nitrogen removals, phosphorous removals, pathogens removals, and other trace organics removals.

In **Jordan**, irrigation using treated effluents is being practiced at a variety of sites adjacent to existing wastewater treatment plants.

However, no data is available on the success of the process and the local criteria used in selecting and designing such systems.

2.2.7.5 Removal of Pathogens

The removal of pathogens in conventional wastewater treatment systems is generally low due to low overall residence time in the treatment plant. Chemically assisted sedimentation steps may significantly enhance the removal of pathogens, such as helminths, in conventional treatment systems with rather high cost. Wastewater stabilization ponds can be designed to achieve virtually complete removal of pathogens.

To remove pathogens from conventional WWTPs effluents, tertiary treatment steps are necessary. Appropriate technology include slow sand filtration, land application, and maturation ponds. The characteristics of pathogens removal achieved by selected techniques are presented in Table 22.

Table - 22: Pathogens Tertiary Treatment Processes (Jordan)
[Table-23, (3)]

Rapid Sand Filtration	Slow Sand Filtration	Land Application	Maturation Ponds	Chlorination
Low pathogens removals	High pathogens removal; suitable for small WWTPs; requires proper operation and maintenance	High pathogens removal, requires proper operation and maintenance to achieve benefits	Effective removal of pathogens; good for small to intermediate size community	Effective for bacteria; not effective for viruses, and especially for helminth ova, and protozoans; expensive; results in chlorinated hydrocarbons formation

2.2.7.6 Septage Treatment

Wastewater and sludge collected by vacuum tankers from residential units not connected to the sewerage systems require appropriate treatment before discharge to the environment. Even in rural areas using on-site seepage pit disposal systems, there is a need for vacuum truck services due to improper design and operation and increased wastewater generation. Two alternatives may be considered in this regard:

1. Discharge septage for treatment in nearby wastewater treatment facilities. However, the existing wastewater treatment plants are not designed with proper handling facilities and capacities to treat such waste loading, which is also variable in terms of its frequency, quantity and quality (high BOD).
2. Septage treatment ponds, similar to wastewater stabilization ponds, designed to receive and treat septage. Such ponds may require the addition of dilution water and special structures for tanker unloading. There is no available local design data for such systems, and development of such data is necessary if such systems to be used.

2.2.7.7 Sludge Management

Sludge resulting from wastewater treatment systems require specific treatment and storage steps before disposal or reuse. There are two methods to achieve effective destruction of pathogens: storage/drying for minimum of one year, and thermophillic composting. Sludge management systems should be based on achieving the minimum cost and pose no health risks. If such sludge are to be used for agricultural purposes, pathogens should be destroyed first. Another alternative for sludge disposal is landfilling, however, landfilling requires appropriate thickening and sludge stabilization steps to improve handling characteristics, reduce sludge mass and volume, and reduce pathogens content. Such steps include sludge blending, thickening, storage, dewatering, and drying. Sludge storage/drying offers a competitive treatment alternative given land availability. Appropriate selection of sludge management practices should be based on a case by case studies, taking into consideration applicable factors such as reliability, and socio-economic factors in terms of sludge reuse.

2.2.7.8 Thermophillic Composting

Composting is a process in which organic material is converted to stable end products. Aerobic composting of biological sludges and septage is the most common process, although anaerobic composting is also possible. Aerobic composting is more rapid and produces less nuisance than anaerobic composting. Properly composted sludge is sanitary, nuisance free, and humus-like materials that can be used for soil conditioning. The degradation of the organic matter in the compost raises the temperature to the thermophillic range 50 C to 70 C which destroys enteric pathogens.

Dewatered or dried wastewater treatment plant sludges are typically mixed with other materials, such as saw dust, straw, recycled compost, and wood chips, to achieve the following benefits:

1. reduce the moisture content of the compost pile to 40% to 60%;
2. increase the air voids for proper aeration;
3. provide structural support and increase porosity; and
4. increase the carbon to nitrogen content in the compost pile to the range 25 to 35 to 1.

The compost pile is then aerated for an appropriate period of time, wood chips are then recovered and the composted product cured and stored for final disposal or utilization. Three types of composting systems are in use today: the aerated static pile; the windrow system; and the in-vessel composting system.

In the Beltsville aerated static pile system (Figure 6; adopted from the World Bank Series), a perforated plastic or steel longitudinal loop pipe system is placed under the pile and a base materials of wood chips is placed on top and around the pipe forming the pile base. The function of the base is to facilitate the movement and the distribution of moving air through the pile and absorb leached liquids. The compost pile is then placed on top of the base then covered with a blanket of insulating cured and screened compost. An exhaust fan then is used to aerate the pile and the effluent air stream is passed through a small pile of cured, screened compost to absorb odors. The pile is then intermittently aerated for up to 30 days then cured for another 30 days.

Compost pile windrows are constructed 1 m to 2 m high and 2 m to 4.3 m at the base. The rows are turned and mixed periodically during the composting period which can go up to 30 days.

The in-vessel composting systems are gaining wider acceptance in recent years because they provide additional control in terms of temperature, and oxygen supply. In-vessel systems produce less odors than other systems, are more rapid, and require less area.

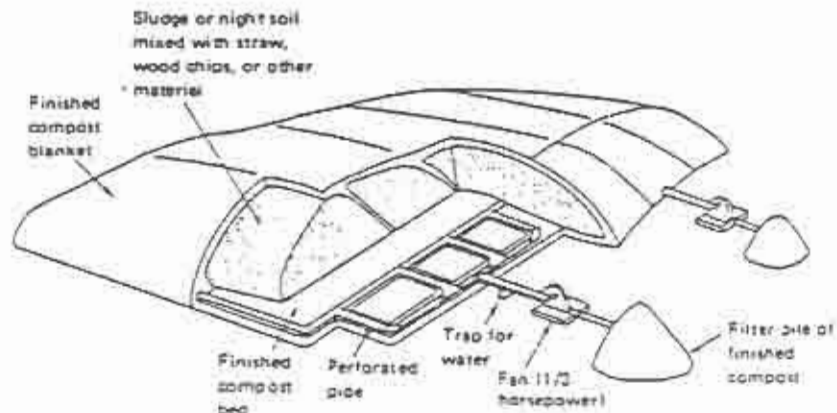
Co-composting of wastewater treatment plant sludges with municipal solid waste has been also demonstrated. The sludge dewatering requirements may be less stringent in this case.

2.2.7.9 Biogas Systems

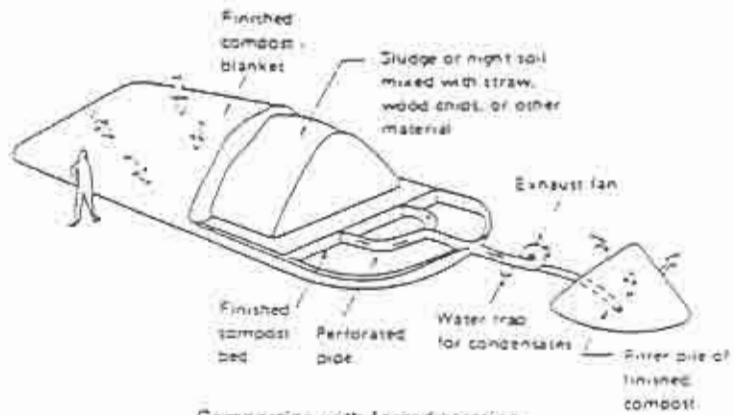
Under anaerobic conditions, the degradation of organic material results in the formation of biogas, a mixture consisting mostly of methane, carbon dioxide, and vapor. Anaerobic sludge digestion is a process used to stabilize wastewater treatment plant sludges and is typically operated at temperatures in the mesophilic range 30 C to 38 C and feed moisture content of up to 99%. Because of the low solids ratio in the influent, the digester requires further heating to reach such temperatures. Thermophilic digestion is more rapid than mesophilic digestion, but requires more energy input. Thermophilic digestion of wastewater treatment plant sludge and septage is capable of destroying enteric pathogens. Because of the high energy requirements, the application of thermophilic composting for biological sludges alone is limited.

Community biogas systems in terms of household solid waste, biomass, animal wastes, night soil, organic industrial wastes such as molasses, and other high organic content materials may be feasible. A variety of reactors are used in the biogas systems. The produced biogas can be used for energy purposes in rural areas for cooking and heating. Biogas systems operating in the thermophilic range are capable of inactivating pathogens. The digested slurries can be used as a source of plants nutrient.

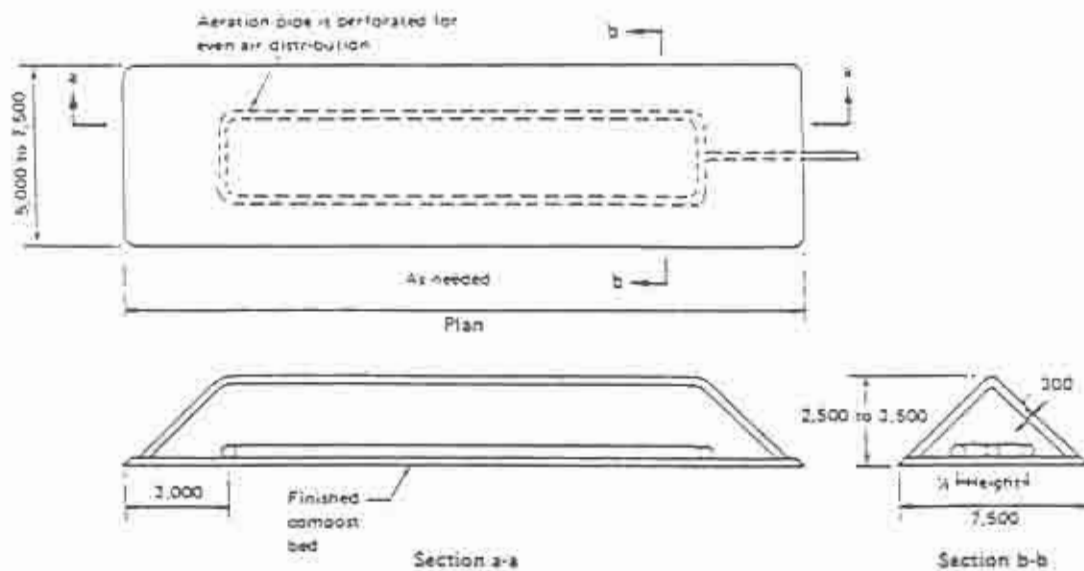
Figure 5. Beltsville Agricultural Research Center (BARC) System for High-rate Thermophilic Composting, (millimeters)



Composting extended piles with forced aeration



Composting with forced aeration



2.3 Appropriate Technology in Tunisia

2.3.1 Goals Set for Rural Water Supply

Before reviewing the various, appropriate technologies used or tested in Tunisia, it is worthwhile to identify the goals sought for rural water supply.

These goals are to make available to rural dwellers a water that is:

- Safe;
- In sufficient quantity;
- Easy of access.

2.3.2 Actions to be Undertaken

To implement these three objectives, the actions to be undertaken consist of:

- The construction of small drinking water supply and distribution networks for concentrated rural population centers;
- For scattered rural populations, increasing the number of water wells or renovating existing water sources.

2.3.2.1 Concentrated Rural Population

It should be noted that concentrated rural population accounts for about 40% of total rural population. A rural population is considered concentrated when there is sufficient density within a radius of 3 km from a social center. For these localities, a supply and distribution network is constructed when existing water resources are adequate for the population concerned.

This includes a production system: wells with a pumping station, a tank, a supply pipe when required, followed by a distribution network which frequently includes stand pipes in sufficient number to bring the water close enough to dwellings. In some cases, where the locality has substantial socio-economic activity, a number of buildings receive individual connections (a school, dispensary... etc.). When the locality is large enough, it is integrated into the SONEDE system which will be operated similarly to so-called urban localities.

2.3.2.2 Scattered Rural Population

As for scattered rural population, which has no domestic wells available, the objective sought is on two levels:

- a- **Renovation of existing water wells:** these wells were mostly fitted with manual drawing devices (bucket or leather container) and were in bad condition with regard to both the solidity of the construction and health. In such cases, it is necessary to strengthen the walls and the lip of the well, to clean it out and deepen it if required, carry out a flow test, and then fit it out and cover it.

**b- Drill More Wells to Ensure Easy Access to Drinking Water:
There are Three Cases:**

- * Where a water table exists, one solution consists of drilling more wells in order to increase the supply in proportion to the population.
- * Where there are natural springs, we have to catch them, purify the water and install stand pipes and watering troughs
- * Where aquifers are not known, it is necessary to conduct water table exploration which might result in creating new wells or, if no aquifer is found, in encouraging the population to build private cisterns to collect rain water.

2.3.3 Alternative Technology

Technical solutions are determinate by the specific features of each locality. They depend upon the present condition of installations, the existence or not of local hydraulic resources and on the extent of community participation.

It should be remembered that the appropriate technology is a set of technological processes which are feasible and viable, approved and accepted by the population concerned and that best serve development goals without necessarily being the best or most spectacular. The main concern is the feasibility of the project.

Appropriate technology is therefore applicable to all project phases: construction, operation, maintenance and control. It lends itself to improvement and to design and equipment standardization. It will be all the more appropriate as it has a greater local content.

Therefore appropriate technology is the whole set of possible technical alternatives to reach the desired development objectives.

2.3.3.1 Selection of the Appropriate Technology

In what follows, we are going to review the constitutive elements of a project so as to justify the selection of the appropriate technology with regard to the assessment of the needs of the locality. However a number of criteria are applied to size the project.

a- Priority criteria:

- * Identification of the present drinking water supply;
- * Socio-economic importance of the settlement;
- * Current supply source (quantity and quality); and
- * Geographic location of the source in relation to the population (distance and ease of access).

b- Sizing criteria:

- * Project duration: 15 years;
- * Population: data updated by the last census, checked in the field;

- * Schools: take 25% as an assumption for schooling rate;
- * Livestock: the number is determined in the field, growth is supposed to be nil because the total figure generally fluctuates around a constant value;
- * Tank capacity: 25% of daily consumption, losses included;
- * Residual pressure: higher than or equal to 5 m at all points of the network;
- * Water losses: 15% of the average daily consumption; and
- * Specific per head consumption:
 - The population: 25 l/d;
 - Schools: 10 l/d;
 - Sheep: 5 l/d.

2.3.3.2 Scattered dwellings:

a- Improvement in quantity:

Actions undertaken consist of increasing the number of water points to raise the flow rate available when the water table has not been identified; or constructing private and public cisterns to collect rain water.

- **New Wells:** The usual technique is the conventional well dug and built up by hand. This takes too long and does not allow the goals of rural drinking water supply to be met.

That is why the DGR experimented with small drilling machines with the aim of substituting drilled wells for manually dug wells.

Under these conditions all the disadvantages of the conventional well will be eliminated: better hygiene, reduced cost, speed of work and consequently a rapid multiplication of water wells to meet the needs of the rural population.

In a second stage, such work can be contracted-out to private operators.

Raising the flow rate of existing wells: this is achieved classically through cleaning out the well and deepening it.

- **Locating New resources:** a complete inventory of water resources in Tunisia is kept by a department in the Ministry of Agriculture, which provides the required information to locate exploitation drilling or new wells

- **Cistern Construction:** this raises no particular technical problem. There are model drawings that are made available to private individuals so they can apply for government financial assistance.

Other models are used for communal cistern. The only problems that may arise are cleaning these cisterns out and, during droughts, replenishing them with water from animal-drawn tanks.

b- Ease of access:

In the case of scattered habitat, the distance of water wells creates serious difficulties. However, a number of solutions have been selected such as:

- Creating as many water points as possible;
- Providing incentives for the renovation of private water points (wells or cisterns); and
- Bringing water on drawn tanks to remote locations deprived of water or whose water resources have been reduced by drought.

c- Quality improvement:

A major preoccupation of the Administration is the quality of the water used by the rural population, a considerable proportion of which is frequently unsafe.

The solutions applied are the following:

- **For water wells:** cleaning out the wells, covering them and substituting motor pumps to manual drawing of water. This protects the well from pollution. In addition the Ministry of Health carries out disinfection on a regular basis.

However, a technology that is considered appropriate in other countries -the hand pumps- has been tried for a few years but it can only be generalized with the wide participation of the community, its education and frequent maintenance of this equipment.

- **For springs:** catching the water and conveying it by gravity to remote locations where it is made available through stand pipes and drinking troughs.

An annual program has been set up to carry out this work and thus generalize safety of spring water and the maintenance of the springs themselves. Greater community involvement would accelerate the expansion of the program.

- **For Public Cisterns (rain water):** The main problem faced by public cisterns is the lack of maintenance because of the want of community participation.

2.3.4 Main Appropriate Technologies Used in Tunisia

A number of appropriate technologies have been tested in Tunisia. We will now describe the most widespread of them.

2.3.4.1 Hand Pumps

Over a period of ten years (1972-1982) many agencies such as the Ministry of Public Health, some regional governorate, and the US organization CARE-MEDICO undertook to renovate 719 wells and fit them out

with hand pumps. Since the end of that program, SONEDE took charge of operations and installed new equipment where necessary in some localities, while in others a motor pump replaced the initial hand pump. It is estimated that about half of the hand pumps are still in operation.

In Tunisia's case, because of the low number of wells needing hand pumps, it is preferable to import these rather than manufacture them locally but it is necessary to procure the spare parts required for a period of five years.

2.3.4.2 Sand Filter

10 to 15% of the population of government districts in North-Eastern Tunisia take their requirements from nearby surface water. A gravity sand filter would be perfectly suitable to allow them to get the volume of drinking water they need.

To achieve the best cost benefit ratio, these sand filters should be sized for 2,000 inhabitants and a life of ten years. Each installation consists of two gravity sand filters (to allow cleaning of one clogged filter at a time), a clean water tank, a disinfection device and if required pumping equipment.

2.3.4.3 Wind Pumps

Wind pumps have been used for a long time in Tunisia on a West-East direction that follows the mountain chain where wind behavior is well known.

The idea is to reintroduce them to supply drinking water to areas that are difficult of access.

2.3.4.4 Underground Rainwater Cisterns

Rainwater cisterns play an important role in the supply of rural drinking water, especially in the center and the south of the country. There are close to 1400 public rainwater cisterns, of which 600 are cracked or unusable. These can be renovated to make the water collected available to scattered populations. Renovation consists of repairing the cracks and lining the cisterns with glass fibre laminate to seal them, as well as in constructing a concrete impluvium covering an area of 100 square meters.

2.3.4.5 Rural Sanitation

A hygienic evacuation of excreta in rural areas is essential if the benefits of a clean water supply are to be achieved.

Individual sanitation facilities are the most suitable in rural areas. Various types of family latrines have been suggested and discussed with the end-users.

The most widely accepted and least costly model is a family latrine with a concrete slab with a hole in the middle, and a reinforced shelter made of a PVC tube frame, while the walls and the roof are of PVC or corrugated sheet.

2.3.5 Conclusion

Any technology, however appropriate or sophisticated will be of no use if it does not enjoy the spontaneous support of the end users and their active participation in the whole project cycle, starting with the concept and following through to planning, design and implementation. Such a participation would stimulate the interest of those involved and their sense of ownership which would prepare them, later on, to agree to bear the operating costs of the systems installed. In this manner, the role of each actor is well identified, the Government carries out the design, planning and work while the Recipients look after operation and maintenance.

For the renovation of existing networks, it would be advisable, prior to choosing a particular technology, to find out the reasons for which the initial equipment has broken down or been abandoned shortly after its installation: e.g. insufficient maintenance, lack of spare parts, large number of users, lack of appreciation by the community of the advantages of the project and so on. Beneficiaries should be asked their opinion about the technology to be used, and be convinced through a health education campaign, of the benefits to be drawn from the project.

The most appropriate type of equipment should be determined case by case: a hand pump does not necessarily have to be replaced by another hand pump...etc.

2.4 Technology Employed In Yemen

2.4.1 Water Supply

2.4.1.1 Traditional Methods

Before 1962, there were three common methods for obtaining drinking water. The use of any one of them depended on the nature of the area and the location of the villages. These methods are:

- a- The hand dug well method.
- b- The surface water method.
- c- The collection of rain water method.

a- The hand dug well method

This method was in use in several rural areas as a main source for drinking water. The wells are not deep and uncovered. Women used buckets to get the water out of these wells and then they carry it on their heads or use donkeys or camels to carry it. The disadvantages of this method are:

- It needs a big effort to get the water out of the well,
- It is time consuming, and
- The water of these wells is liable to pollution which may cause a number of diseases.

b- The surface water method

In some areas, surface water is available specially during the rain season. Springs are the main source of this water which runs into the valleys, people drink from this water directly and without any treatment and on effort is needed to obtain this type of water except carrying it into the villages.

The disadvantages of this source are:

- The water is much more polluted with bacteria and harmful pathogens, and
- The people suffer from a number of diseases much more than people who use hand dug wells.

c- The rain water collection method

In the mountainous areas and where the distance between the villages and neighbouring valleys is very long the rain water collection systems were in use by two ways:

- 1- The first way: when every house-owner builds a tank near his house to cover his needs of water. The tank is covered. Special arrangements are taken to collect the water during the rainy season in order water to reach clean and clear of dirt into the tank.
- 2- The second way: when big ground tank is constructed in the village. This tank is uncovered and water is collected during the rainy season into this tank and used by the villagers during the remaining of year.

Because the tank is uncovered and the water collected reach to the tank through canals this source of drinking water is not clean and cause a number of diseases.

2.4.1.2 Appropriate Water Supply Technology for Rural Areas

In the 1960's, a new technology for supply of drinking water was introduced. Deep wells drilled and groundwater was pumped for drinking and irrigation purposes.

This method began in the main and secondary cities. Then and after the establishment of the rural water department, in 1970's, it expanded to include the rural areas. International organizations like the USAID, (WHO) and the Netherlands Government and some Arab countries played an important role in the establishment of a number of rural water supply projects. The using of the new technology was a very important step to provide clean water to the rural areas and spared people efforts and suffering of the past.

On the other hand, when we come to the problems of this new water technology we will find the following:

1. It is costly construction and operation process, and

2. Yemen is one of the arid and semi-arid areas which suffers from the scarcity of water, therefore, the using of this new technology depleted the water aquifers. In addition, the using of groundwater for irrigation purposes increased the problem of depletion and affected the water supply projects in a number of governorates.

On this basis, there is a need for other water resources to reduce the groundwater depletion as well as the costs of the water supply projects. As a suggestion, new technologies and alternatives should be used. The choosing of these new technologies and alternatives should be subjected to the following conditions:

- It should provide low costs social services,
 - It should have a positive environmental and health effects, and
 - It should be suitable to the different situations of the rural areas.
- The suggested technologies can be summarized as follows:

- 1) Collection and storing of rainwater

This method is not a new one but it should be developed to make a full use of the rainy seasons which fall heavily in most of the rural areas and the collection process will reduce the groundwater depletion and will not cost much.

Two ways are proposed to collect the rain water:

- A. In the spread houses areas

Suitable size tanks built of stones can be established to cover the needs of a house or two houses during the absence of rain. Rain water can be collected from the surface of the house or from any other clean place into the tank as it is happening in some of the mountainous areas like Taiz. This method is called (water harvesting) the tank must be covered, clean and not liable to pollution.

- B. In areas of neighboring houses and population density

Tank or tanks can be built in a suitable locations, water can be collected through clean canals. The tank must be protected, covered and not liable to pollution, a pumping station can be installed to pump water into the houses. The estimated consumption is (10-20) liter per person per day Therefore , a tank of 500 m³ quantity will be sufficient for ten houses and for seven months duration, more than one tank can be built in the villages.

- 2) Using of the surface water after filtration in some of the rural areas

Surface water which comes from the springs and runs into the valley is considered the main sources of water supply used by the villagers. Women carry water from the valleys on their heads to the villages or use donkeys and camels to carry it. This type of water is considered as source of several diseases such as: Dysentery, Malaria and Gardia.

To prevent these diseases and to improve the quality of surface water, healthy methods should be implemented. It is suggested here to establish filtered screen made of retaining wall sand and gravels which can be established then the filtered surface water can be collected and pumped to the villages, this method was implemented to a certain limit in some areas like Hajja city and Al Mehweet city.

3) The establishment of dams for water supply and irrigation

The geography of Yemen, the natural diversity of elevations, the spread of mountains surrounding the valleys all over the country and the fall of heavy seasonal rains proved suitable conditions for the establishment of dams which were a part of the country history and the Yemeni civilization. The concerned Yemeni authorities in Yemen like the Ministry of Agriculture and Water Resources are planning to build number of dams to stop the increasing depletion of the ground water. The using of the groundwater supply for irrigation purposes and fear if increasing depletion strongly support this policy.

The establishment of dams, even of small size ones, in suitable locations will provide source for water supply project. Wells can be drilled around these dams and water can be pumped to the neighbouring villages.

2.4.2 Sanitation

Sewage is being treated by stabilization ponds in Taiz, Hodeidah, and Dhamar. In IBB, a new extended aeration treatment plant was installed in 1991. In Sana'a, sewage is treated through temporary ponds. In Greater Aden, part of the sewage (25%) is treated in stabilization ponds and the rest is discharged into the sea.

The objective for future is to improve sanitation in urban and rural areas all over the country

2.4.2.1 Proposed Sanitation Technology in Rural Areas

To have a suitable and successful technology for sanitation in the rural areas, the following conditions are very important:

1. Establishment of an authority to be in charge of sanitation and to prepare plans, programmes and instructions, and
2. Rurals should participate in the costs of the new sanitation methods.

2.4.2.2 Proposed Sanitation Technologies

1. Pour flush toilette method.

This type of toilette can be used in area of rural water projects while 50% of rural areas of the Republic of Yemen are covered by water supply projects. This type can be widely used especially the offset pit design which is more suitable with the main advantages of no odour or fly and mosquito also minimal risk to health.

It is not costly, easy to construct and can be considered as intermediate solution as it is in the case of septic tank.

2. Pit privy latrine

The pit privy is very simple in design, construction, maintenance and can be used in rural areas where there are difficulties in obtaining water, the toilette can be built here within the house.

It is a low cost type and easy to construct. When it is kept clean, it has good advantages of no odor, fly and mosquito with minimal risks to health.

3. Pour Flush/Septic tank soak away/latrine

This type can be implemented in the rural areas where water supply is available. On one hand, the method will reduce the problem of pollution, and on the other hand, the construction of a sewerage project in the future will be less costly. In addition, the treatment process will be very simple.

However, in all previous proposed types of sanitation latrines it is very important to abide by the regulation of the WHO related to the sanitation systems which are as follows:

1. The surface soil should not be contaminated,
2. There should be no contamination of groundwater that may enter springs or wells,
3. There should be no contamination of surface water,
4. Excreta should not be accessible to flies or animals,
5. There should be no handling of fresh excreta, when this is indispensable it should be kept to a strict minimum,
6. There should be free from odors or unsightly conditions, and
7. The method used should be simple and inexpensive in construction and operation.

3. Operation and Maintenance

3.1 Water Supply and Sanitation and Water Resources Management, Iran

- Choosing available low cost water supply and sanitation technology.
- Rehabilitate existing malfunctioning systems and correct operation and maintenance inadequacies, before investing in new system,
- Conjunctive application of traditional and modern system of wastewater projects,
- Developing technical standards in water and wastewater projects,
- Strengthening and capacity building for information management and technology transfer at sub-national levels,
- Development of twin distribution systems and bottled water in dry areas,
- Planning for the repairs of the distribution networks to prevent losses,
- Allocation of the polluted well waters to irrigate green area,
- Development of the high efficiency irrigation systems (e.g. Drop irrigation and sprinkling irrigation systems) in the urban green areas, and
- Use of limited flow valves in the houses.

3.2 Operation and Maintenance, Tunisia

The experience of DGR and bilateral aid agencies has shown that public installation of rural water supply do not work satisfactorily when there is no supervision by the community concerned.

The problem of operating rural water supply systems became acute towards the end of the 6th development plan (1981 - 1986) owing to the high number of settlements served and the size of investments made: 613 pumping stations and 812 drinking water tanks had been commissioned, which requires a considerable operation and maintenance budget.

3.2.1 Before the Creation of AICs*

Operation is the responsibility of the regional administrative authority. The Ministry of Agriculture, acting through its regional office, provides technical assistance and sometimes helps with maintenance.

Operation and maintenance vary according to the case in point.

* AIC: Association d' Interet Collectif (Community Association of Users)

3.2.1.1 For Fully Equipped Systems

Which normally consist of a water point (drill hole or surface well), pumping station, tank supply pipe, tank, distribution network and outlets: stand pipe, trough, connection of public buildings such as schools, dispensaries, mosques,..etc.

A guard is recruited locally to carry out the following tasks:

- Operation of the equipment,
- Maintenance of the equipment : daily maintenance, changing the motor-oil
- Watching over the station and the network,
- Occasionally, selling water cisterns, and
- Maintenance and cleaning of the pump building.

The council of the governorate bears the cost of the fuel or electrical power required as well as the guard's salary and spare parts. When there is a failure, the guard reports it to the authorities who then advise the local DGR office asking for a technical diagnosis and a list of spares required if any are needed. The placement of the order and payment therefor are the responsibility of the Regional Administration Authority. It is obvious from the above that this procedure involves many entities that have other concerns and priorities at the regional level, with the result that the failure may last for a long time, depriving people from drinking water, which makes the recipient community lose all confidence in this system.

3.2.1.2 For Stand-Alone Systems

Public wells, whether fitted with a hand pump or not, unprotected springs, rain water cisterns. Their maintenance is even more difficult because of their number, of the fact that they are widely scattered and of the limited means available to DGR which do not allow systematic maintenance of all public water wells.

With regard to those public wells that are neither equipped nor covered, an annual maintenance program is jointly prepared with the Environmental Hygiene Department in the Ministry of Health, and the Regional Authorities.

The necessary funds come from the Ministry of Agriculture for the procurement of equipment and materials and from the governorate council for labor expenses.

The Ministry of Health helps with the maintenance of public water wells through water quality control and decontamination of surface wells and rain water cisterns. However, it should be noted that no work carried out in relation to the operation and maintenance of drinking water supply systems is of a preventive nature. In actual fact, because of the scarcity of their means, DGR teams are only involved when there is a failure at the pumping station or following an investigation showing the un-drinkability of water from un-equipped and uncovered wells or from unprotected springs. In addition, the stock of spare parts available in the DGR store is not large enough to meet the demand. Therefore, there is no periodic inspection of

the pumping stations for maintenance purposes (replacement of certain parts after a given period of operation, oiling etc...), resulting in a need to replace equipment much too early, which increases the cost price of water distributed.

3.2.2 After the Creation of AICs

Since the problems gained in complexity as the number of water points went up, the Government felt the need to involve recipient communities in the management of water wells and have them contribute to operational costs. This initially timid approach yielded good results, which encourages DGR to extend it throughout the country and give it a legal base. In October 1987, a series of laws establishing the organization and operation of GIHs and AICs was promulgated. A model of Articles of Association for AICs was published in January 1988. An AIC is incorporated to manage the water well, while work is still in progress on the well or on its renovation. This incorporation is a condition precedent to obtain a grant. Further technical improvements were introduced to solve some of the problems encountered:

- Standardization of equipment,
- Inclusion, in the hydro-mechanical equipment purchase order, the required quantity of fast wearing parts for 5000 hours of operation so as to avoid any loss of time when these parts needs to be ordered, and
- Provision of standby equipment to maintain water distribution during repairs.

The increased cost generated by these steps is about 10% of total project cost, but it ensures continuity of the project.

The involvement of the local community in the design and selection of the appropriate technology helps with the final success of the project. Local labor and materials are used for construction whenever possible.

The future guard is chosen among the people who took part in the project implementation which means that he will be familiar with the installation and have participated in the start-up of equipment. He is given adequate further training to enable him to carry out his duties properly.

3.2.3 AICs' Role in Operation and Maintenance

Changes made to the water code in July 1987 specify the part to be played by AICs' in operation and maintenance.

They relate to:

- Operation of water points,
- Performance, maintenance or use of works in relation to public domain water assigned to AICs,
- Irrigation or sanitation, and

- Operation of drinking water systems.

This shows that all the responsibilities required have been conferred upon AICs to allow better exploitation of water wells by users and ensure proper operation.

The water code also stipulates that operating costs are to be borne by the recipients. When equipment needs to be renewed, though some contribution may be made by AICs, the necessary funds come from the Government.

However the budget of AICs essentially covers the maintenance, repair and operation of the wells under their responsibility.

3.3 Needs and Requirements for Operation and Maintenance in Yemen

Operation and maintenance are very important. A large proportion of failures or under - utilized system can be attributed to faults in the operation or maintenance. The main needs and requirements for operation and maintenance for water supply systems are as follows:

- a) Good initial community involvement leading to a feeling of ownership among the users,
- b) Good training and education of the staff identified to carry out the operation and maintenance,
- c) Appropriate machinery or equipments to the physical conditions, e.g. heat, dust ..etc.,
- d) Availability of spare parts to enable proper operation and maintenance, and
- e) Adequate financial for operation and maintenance. The rural sanitation is expected to continue on-site through pit latrines or pour flush latrines systems which will need an appropriate selection, design and construction.

4. Institutional Set Up - Institutions and Agencies

4.1 Institutions and Legislation in Jordan

The Water Authority of Jordan, as part of the Ministry of Water and Irrigation, is responsible for water supply and sanitation in the country, including resource development, construction, operation, maintenance, planning, training, conducting research, and formulating water policies and strategies. Municipalities and local village councils, assisted by the Ministry of Municipalities Rural Affairs and Environment, are responsible for urban planning, solid waste collection, and citizens safety. The Ministry of Health monitor the quality of drinking water supplies and the disposal of excreta and wastewater. Other governmental and non-governmental organizations involved in environmental health monitoring and related environmental concerns include:

1. Ministry of Agriculture
2. The Greater Amman Municipality
3. The Higher Council for Sciences and Technology
4. Jordan's Public Universities
5. The Royal Scientific Society
6. Jordan's Meteorological Society
7. The Armed Forces
8. Occupational Safety and Health Institute
9. The Royal Society for Conservation of Nature
10. Jordanian Society for Control of Environmental Pollution
11. The Jordanian Society for Badia Development and Combatting Desertification.

4.2 Institutional Setup in Tunisia

Rural drinking water and sanitation strategies have been suffering from a major drawback related to the institutional setup of the sector. This goes to explain the inadequacy of the results achieved despite the magnitude of the means made available.

The large diversity of operators and Government Agencies concerned and the lack of basic structure for user participation are at the origin of the difficulties and insufficiencies noted in rural drinking water system operation and management.

4.2.1 Government Agencies and Operators

4.2.1.1 The Main Operators

The two main operators in rural drinking water supply are:

- The Department of Rural Engineering (D.G.R), Ministry of Agriculture; and
- The water utility company (SONEDE).

The scope of responsibility of each of the above was identified in the 6th development plan, which puts SONEDE in charge of supplying settlements of more than 250 inhabitants and leaves the remainder to be looked after by the DGR.

- The sanitation utility (ONAS) does not operate in rural areas.

4.2.1.2 Government Agencies

They play a considerable role at all stages of project life, from planning to work follow-up.

- Planning: The government agencies concerned are:
 - * Ministry of the Plan (general Directorates of Planning, Projects, Budget);
 - * Ministry of Agriculture: Directorates of Studies and Planning, Water Resources, and Rural Engineering;
 - * Regional Government Districts (Governorate).
- Implementation: The implementation of certain water and sanitation projects by these agencies is exceptional and is designed either to meet a specific need or serve as a pilot project. These agencies are: the Regional Government Councils, the Ministry of Health and the Regional Development Authorities.
- Financing: The Ministry of the Plan provides funds through the Regional Development Programs, the projects of the Ministry of Health (Pilot Project) and those of the Regional Government Councils.
- Monitoring: The monitoring of work performance is the responsibility of the DGR while water quality controls the duty of the regional offices of the Ministry of Health.

4.2.2 Management and Operators

A distinction should be made between the management of SONEDE network and that of DGR network.

4.2.2.1 SONEDE:

Conducts management, maintenance and repairs of its networks as well as controlling the quality of the water distributed. In addition, SONEDE takes over, in certain cases, responsibility for rural centers established by DGR.

4.2.2.2 DGR:

Management of water points set up by DGR is the responsibility of the rural communities. The councils of the Regional Government Districts allocate every year a budget that has been constantly increasing, to the point where, in certain districts, it accounts for most of budget expenditures.

The lack of water point maintenance is the major problem, reducing markedly the efficiency of the programs and investments implemented. The proportion of abandoned wells (close to 25%) goes to confirm the seriousness of this problem. This is closely linked to the Institutional vacuum which has long been a feature of project management.

4.2.3 Institutional Framework for Project Management

The problem lies in the lack of a body to coordinate the different operators in rural areas. A part from the Governor or the Secretary General of the governorate, there is no official that has the authority to convene all the operators concerned by drinking water and sanitation

Furthermore, employees of the various regional bodies involved (SONEDE, DGR, Health etc..) are not used exclusively for rural drinking water: the SONEDE's regional districts do not have divisions specialized in rural water supply, DGR divisions also responsible for agricultural activities and Ministry of Health employees are responsible for all aspects of public hygiene and health education.

As for sanitation, there is no institutional framework which is administratively in charge of it. This vacuum is felt by all the operators and all those who have an interest in this sector.

The various solutions contemplated converge towards increased participation by the population concerned. And the Ministry of Agriculture has actually promulgated legislation organizing such participation in 1987 and in early 1988.

4.2.3.1 The Legal Basis for User Associations

Association of users were provided for by Articles 153, 154 and 155 of the water code promulgated by Public Law No. 75/16 dated 31st March 1975. However, this code deals only with the setting up of Agriculture water users associations and does not refer to rural drinking water users

To correct this oversight, Public Law No. 87/35 dated 6th July 1987 sets forth provisions covering Community Associations (A.I.C), and further legislation was adopted to implement those provisions with respect to Users' Associations.

- Public Law of 6th July 1987 introduced the name of Community Association (AIC) to replace Owners' and Users' Associations and assigned them the following goals:
 - * Operation of water resources from the public domain in their area of responsibility: carrying out the work required, maintenance, etc...
 - * Operation of the drinking water system.
 - * Decree No. 87/1261 of 27th October 1987 provides for the formation and operation of AICs.
 - * Decree No. 88/150 of 12 January 1988 supplies model Articles for AICs.

These AICs are independent legal entities which can be setup either by the users themselves or by the Administration at the Local or Regional level.

4.2.3.2 Organization and Operation of AICs

Decree of 27th October 1987 stipulates that AICs are placed under of the authority of the Governor. They are incorporated by a departmental order of the Ministry of Agriculture, following the advice and opinion of the Regional Hydraulic Resources Committee. When it is deemed necessary, the Governor can decide to incorporate an AIC.

AICs are administered by a Board of Directors consisting of 3 to 9 elected members, assisted by a manager and an accountant nominated by the administration. The local tax collector is responsible for the financial management of AICs.

Their budget is divided into two parts: firstly, operation, maintenance and repair, and, secondly, new works.

The income of AICs consist of subscription paid by members, proceeds of water sales, loans taken out, possible subsidies from the government or local authorities, as well as from gifts and legacies.

The amount of subscriptions is determined by the AIC Board of Directors. It becomes payable as soon as it is approved by the Governor.

4.2.3.3 Organization and Operation of Regional Hydraulic Resources Committees: GIH*

This Committee is chaired by the Governor and consist of representatives of the Ministry of Planning and Finance, the Ministry of Public Health, and the Ministry of Agriculture, the Regional Chief Officers of the DGR and the Water Resources, SONEDE representative, Regional Delegate of the Farmers Union, as well as 7 members representing the AICs of the governorate concern.

The secretariat of this Committee is the responsibility of the Regional Representative of the Ministry of Agriculture, Committee Members are appointed by the Ministry of Agriculture on the basis of nominations by the Governor concerned.

GIH has a technical responsibility to manage local water resources.

* GIH: Groupment d' Intere't Hydraulique (Regional Resources Committee)

4.2.4 Conclusion

All these institutional provisions helped considerably in improving local management of rural water supply and encourage stronger community participation.

Once the institutional framework established, the next step was to promote the setting up of AICs in all areas where a water supply or sanitation project is scheduled.

Following a public hygiene educational campaign and as soon as the community expresses the wish to create or renovate a water supply system, a temporary management committee - that will, in time, become an AIC - is established. This approach which focuses on active participation from the users ensures successful operation of the project and the durability of the program.

4.3 Institutional Setup in Yemen

The institutions for water sector are:

1. The National Water Supply and Sanitation under the Ministry of Electricity and Water (NWSA) is responsible for both drinking water and sewerage in the urban areas (towns) in the northern and southern governorates. The Public Water Corporation (PWC) is responsible for supply of water in urban and rural areas.

PWC after unification became under NWSA and both NWSA and PWC established Branch offices in few governorates.

Sanitation in the urban areas in southern governorates is the responsibility of the Ministry of Municipalities.

2. The General Authority for Rural Electricity and Water under the Ministry of Electricity and Water is responsible for supply of water for rural areas by constructing the networks and handed over to the local council for operation and maintenance. In the southern rural areas the PWC is responsible for water supply and it is similar to northern governorate the systems are operated by local council.
3. The Ministry of Agriculture contributes to rural water schemes in the northern governorates through rural development schemes in different regions.
4. There is no institutions responsible for sanitation services in rural areas, little is done by the Ministry of Health.

5. Environmental Health (EH) Institutions

5.1 Environmental Health in Jordan

5.1.1 Training

Jordan is blessed with its human resources and educational institutions. The education and training system quality is generally high and is widely recognized in the region. Typically, Jordan supplies high quality experienced human resources to nearby countries. With proper incentives, planning, and management, there should be little if any deficiency in locating human resources with reasonable degree of specialization. However, financial and institutional constraints are limiting, to some extent, the employment capacity and quality of health, water and sanitation agencies.

The Ministry of Health has established in Amman, in 1973, an institution to train technical staff including health inspectors. Another institutions was established in 1982 in Irbid. In addition to formal training, the Ministry of Health organizes training courses in water supply and sanitation. Newly hired health inspectors undergo four weeks of pre-job training. Although the numbers of health inspectors in the ministry is increasing continuously, the number of employees in other specialities, such as sanitary engineering and general health specialists has not increased.

In 1983, the Water Authority established a center to train and improve its staff capabilities through local and international courses, seminars, and field visits. Between the years 1983 and 1991, the center conducted 93 local training courses and trained 2036 employees in various vocational and technical specialities. The total number of training activities during the same period was 109 with a total participants of 2392 including visitors from neighboring countries. The center also coordinates activities with related international organizations. The total Number of employees at The Water Authority was 6489 in 1991, including personnel from a broad range of related specializations, levels of training, and academic education. The total number of employees increased from 5002 in 1986 to 6587 in 1990, then decreased slightly in 1991 to reach 6489. The Water Authority publishes a yearly report on its major achievements, plans, and activities.

Nevertheless the above achievements, there remains a constant shortage of quality operators especially in the treatment field, where the operators skills does not match, in many instances, the sophistication of the used technology to allow effective utilization of the technology to the desired level. In addition, the incentives may not be adequate enough to attract and retain specialized, and highly trained operators.

5.2 Health For All By The Year 2000, Tunisia

Simultaneously with the efforts made by the Ministry of Agriculture and the various operators in the areas of drinking water and sanitation, the Ministry of Public Health has been making unremitting efforts to achieve the goals of Health for All by the year 2000 (HFA 2000).

The main lines of HFA-2000 were laid down in Tunisia well before 1978, the date of the Alam Ata Declaration as evidenced by the efforts made for the benefit of Mother and Child Health (1959), Family Planning (1964), the Fight Against Malnutrition and other social diseases, the growth of Industrial Medicine, the extension of drinking water supply (mid-70s).

However the strategy and action plan responded with greater clarity to the Health For All goals after the Alam Ata Declaration on primary health care. Many changes were made:

- The replacement of the Social and Preventive Medicine Directorate by a Primary Health Care Directorate and the creation of new directorates: Environmental Hygiene and Protection, School and University Medicine (June 1981) and Design and Planning.
- The appointment of Chief Medical Officers for Primary Health Care in all Governorates.
- The formulation of a National Action Plan and Regional Action plans on Primary Health following the first national seminar on this type of care (December 1981).
- The earmarking of the funds for the primary health care program (23% of the operating budget of the Ministry of Health are allocated to Primary Health centers and village hospitals).

It is noteworthy that all the international aid resources and most of the medico-social investments go into the budget of Primary Health care:

- The law was also adjusted to the requirements of Health For All:
 - * Marketing of Mother's milk substitutes according to WHO recommendations (1983);
 - * Compulsory vaccination: measles (May 81), whooping-cough, diphtheria, tetanus (September 87), polio (January 76) and tuberculosis (February 59);
- The establishment of local health councils in most sub-governorates in order to promote community participation.
- Incentives to Non-Governmental Organizations in a position to promote access to health: Tunisian Women's organization (UNPT), Rural Development Associations (ASDEAR), Tunisian Organization for Education and the Family (OTEF), Health For All Association...etc.

5.2.1 Interdepartmental Cooperation

Other Ministries have contributed, each to the extent of its responsibility, to improve the health condition of the whole population:

- The Ministry of Agriculture, as explained in detail in the preceding chapters, has been making a major contribution to the achievement of health for all goals by making safe drinking water available to the remotest districts. In addition, through its Integrated Rural Development Projects, it helps provide for the health component, including the primary health centers.

- Furthermore, once dams are constructed by the Ministry of Agriculture, the Ministry of Health always comes in to prevent potential health problems (bilharziasis, malaria...).
- SONEDE and ONAS deploy praiseworthy efforts to extend their services to an increasing number of settlements;
- The Ministry of Economy also contributes to support health by subsidizing primary foods (bread, oil, sugar);
- The Ministry of Education also plays a part in promoting health by introducing health education subjects at all school levels. It is intended to use educational media in the near future;
- In this connection, the Ministry of Information has been assisting the Ministry of Health by making available all the audio-visual media (radio, T.V, newspapers) to sustain health education campaigns.

These campaigns are conducted by local Health employees with frequent assistance from locally established NGOs, using the following means: direct contact, posters, newspaper articles as well as the radio and T.V and in school and training centers for rural.

5.3 Environmental Health Institutions, Yemen

There are acute environmental health problems in both urban and rural areas. Significant percentage of urban population live in areas without basic sanitary facilities and with inadequate water supplies. The absence of essential services like sanitary disposal of sewage and refuse threatens the health and well-being of people living in marginal settlements. The present institutional set up is not in a position to take a leading role in developed integrated environmental health service. This is mainly because programme policies are not defined and planners and programme managers are not sufficiently qualified nor sufficiently aware of the importance of the environment for sustained development and of the impact of development on the environment.

Adverse effects on the rural areas sanitation where rurals began to use plastic pipes for the sewers extend the pipes to the roads, canals and valleys. This situation created very bad environmental effects which reflects on the health of the rurals and increases the danger of spreading diseases. On this basis, there is an urgent need for a new technology to improve the sanitation situation in rural areas.

Intermediate solution is the use of septic tanks. This method can be used in areas of rural water projects.

Institutional organizations are very poor and ineffective. They are presently limited to ineffective monitoring of few pollution sources and food safety. There is no clear perception of the major environmental health problems.

The existing structure of the environmental health management institutions is as follows:

- a. The Directorate of Environmental Health of the Ministry of Housing and Urban Planning;
- b. The Directorate of Public Health of the Ministry of Health;
- c. The Department of Occupational Health of the Ministry of Health;
- d. The Environmental Health Department of the Major Municipalities.

Each of these departments have assumed their responsibilities with little or no coordination.

6. Inter-Agency Collaboration

6.1 Inter-Agency Collaboration, Iran

6.1.1 Water and Wastewater Companies

The most important feature of water industry has been the establishment of successful water and wastewater companies. Before this reform, there was not any defined authority for water and wastewater organizations.

In 500 cities, 50 of them were ruled by the Ministry of Energy and the rest were organized by city municipalities.

According to the new law the Ministry of Energy is responsible to establish the independent companies of urban water and wastewater for each province.

At the present time such companies have been established in 25 provinces and 5 big cities. The Under-secretary of urban water and wastewater affairs of Ministry of Energy is the director of the program. The main purposes for such companies are:

- Self Sufficiency
- Non government status
- Uniform laws
- Training
- Promotion of efficiency
- Development

Works for the establishment of such companies is an important achievement in the last decade.

6.1.2 Training

Training programs and seminars, etc., issuing a magazine for water and wastewater, establishing university and college programs in related fields.

6.2 Inter-Agency Collaboration, Jordan

The need for appropriate management of Jordan's limited water resources, previous fragmentation of institutional responsibilities and competition, lack of coordination, duplication of efforts, and close ties between water supply and wastewater collection and disposal called for the establishment of a single responsible agency.

The Water Authority of Jordan, created by law in 1983, has independent financial and administrative status. The major responsibilities of the water Authority may be summarized as follows:

1. Total responsibility for drinking and industrial water supplies, wastewater collection, water reservoirs, and all associated projects and services.
2. Establishing policies for exploration, development, and consumption of water resources, with the overall objective of ensuring proper supplies in terms of quantity and quality for municipal, industrial, and irrigation purposes.

3. Construction, operation, expansion, maintenance, upgrading, and management of water treatment and distribution systems.
4. Construction, operation, expansion, maintenance, upgrading, and management of wastewater treatment and collection systems, and planning water reuse
5. Training on all aspects of national water supply and sanitation, including participation in national and international related activities.
6. Conducting theoretical and applied research pertaining to water supply and wastewater systems.
7. Establishing standards, conditions, and specifications necessary for the protection of water resources from contamination and the safety of physical structures.

In addition to monitoring the quality of potable water, the Water Authority monitor, through its laboratories, the quality of effluents from wastewater treatment plants, industrial discharges, and the quality of streams and reservoirs. To ensure effective monitoring, the Water Authority works diligently at:

1. Improving the capabilities of analytical laboratories by providing them with the necessary hardware, supply chemicals, and trained, experienced personnel.
2. Improving and expanding the sampling and monitoring networks.

The administration of The water Authority consists of a central administration in Amman, and administration offices, one in each of Jordan Governorates. The Secretary General's office supervises five divisions, with each division consisting of several directorates. The secretary general of The Water Authority reports to the Minister of Water and Irrigation office. The central five administrations are: Water resources; projects; operation; maintenance; and workshops; finance and administrative affairs; and planning, development and information. Organizational structure of each governorate consists of four directorates: Planning, Studies, and Information; Operation, Maintenance, and Workshops; Subscribers; and Finance and Administration.

The recently (1993) promoted Directorate of Environmental Health at the Ministry of Health, monitors, through the Department of Environmental Inspection, potable water supplies, wastewater, and effluents from WWTPs. In addition, the Directorate collects statistical health data, conducts training programs, and plans and implements health care program. Before 1993, the above activities were directed by the Department of Environmental Health under the Directorate of Primary Health Care, a set-up that partially restricted the effectiveness of environmental health monitoring. The new organizational structure is expected to enhance the role of the ministry in monitoring the water and sanitation systems in the country. The specific monitoring tasks conducted by the Ministry of Health include:

1. Field inspection of public and private water sources.
2. Monitoring potable water supplies to ensure proper quality and chlorine residual.

3. Monitoring private water supplies by tankers and other commercial drinking water supplies.
4. Monitoring public water supplies, hotel water supplies, and waters used in food products manufacturing.

The Ministry of Health prepares monthly and yearly reports on its water quality findings. In addition, the Ministry have the authority to monitor the sanitation situation through participation in the selection of treatment sites, routine inspection of WWTPs, routine monitoring of WWTP effluents, monitoring of crops irrigated with treated effluents, and monitoring of solid waste disposal sites.

In general, the level of legislation associated with environmental health, including water supply and sanitation technologies requires significant improvements in Jordan. The public health law introduced by the Ministry of Health in 1972, is concerned with various aspects of water supply and sanitation. The law gave the Ministry of Health the authority to monitor water resources for protecting against spread of infection, ensure that potable water supplies are properly treated and chlorinated before distribution to consumers, prevent the distribution of unsafe drinking water, supervise water distribution networks during and after construction, supervise waste disposal sites, and prevent the construction and operation of disposal sites that pose threats to water resources. The public health law also requires that all waste collection and treatment systems comply with established health standard, and protects against improper waste disposal.

Proper legislation to protect water resources, ensures proper implementation and response, delegates responsibilities, sets standards, specifications and quality control/quality assurance procedures, and assigns liabilities and penalties which is urgently needed in Jordan.

In order to organize the national environmental efforts, an environmental department was established in 1980 as part of the Ministry of Municipalities Rural Affairs and Environment. The Ministry put forward a comprehensive law dealing with various aspects of environmental issues. Currently, the law is under study for ratification. The proposed law covers 12 sections. Section 1 deals with general rules and regulations. Section 2 calls for the establishment of a general Department of the Environment. Section 3 establishes a fund for environmental protection. Section 4, 5, 6, and 7 deal with water, air, soil, and Flora and Fuana. Section 9, 10, and 11 deal with permits, insurance, responsibilities, penalties, and liabilities. The final rules and regulations are covered in section 12. Although most institutional programs are independently created and implemented, the planning policies and strategies are common. There is a significant amount of information exchange between the different organizations. The water supply and sanitation tasks delegated to the various governmental institutions are generally properly defined, especially in urban areas. The Water Authority of Jordan is the supplier of water supply and sewerage services in urban and rural areas, and the Ministry of Health monitors the health aspects of water supply and sanitation. Many other GOs and NGOs are involved in monitoring water resources and the contamination of resources. Monitoring efforts by the various organizations are generally not properly coordinated. Significant coordination improvements can be achieved in that regard with the proposed creation of a general Environmental Department.

Although all concerned organizations try their best to cooperate and coordinate their efforts, some cite hidden authority conflicts, lack of seriousness in implementing health measures, improper penalties, and inadequate rules and regulations. Inter-agency collaboration requires specific mechanisms and budgets which are not generally available, especially within the responsibilities and the limited budgets assigned to the different agencies. In addition, and in some instances, limited budgets prevent undertaking necessary health related corrective actions recommended by monitoring agencies.

The Ministry of Public Works and Housing specifies standards for proper construction of on-site excreta disposal systems. Municipalities and local village councils have building and health inspectors to supervise and monitor rural sanitation practices. Such standards, however, are rarely enforced, and instead, on-site sanitation practices are built according to traditionally accepted methods. Enforcing on-site disposal codes in rural areas is generally enforced in response to complaints from affected parties.

6.3 Inter-Agency Collaboration, Tunisia

As we saw in the preceding chapter, the large number of bodies involved was for a long time a handicap for this sector. However, there is definitely a willingness to cooperate and actual collaboration between the major operators.

6.3.1 SONEDE - ONAS Collaboration

With respect to the Urban Sector, one might think it abnormal to separate water supply from sanitation, all the more as in most countries they are combined into one corporation.

In Tunisia, many factors have promoted the separation of the two utilities:

- Prior to the creation of ONAS in 1974, it was initially planned to charge SONEDE with sanitation. Implementation of this idea was started with SONEDE being made responsible for the management of the first wastewater treatment plants in the Jebra Tourist resort.
- But four factors argued in favor of two distinct entities:
 - * The large amounts of investment required for each;
 - * The complexity of existing water supply and sanitation networks;
 - * The different approaches necessitated by the nature of the work, operation, treatment, maintenance for each system; and
 - * The size of Tunisia makes it cost/efficient to separate the two entities.

That is how ONAS was setup independently of SONEDE but maintaining close collaboration with the latter.

6.3.1.1 Organic Collaboration

There is a close relationship at the highest level since the Chairman and CEO of SONEDE sits on the Board of Directors of ONAS and vice versa. The second means of organic collaboration is commercial: SONEDE is charged with collecting on behalf of ONAS the sanitation charges which are listed in a separate column on SONEDE bills.

Moreover, the first boss of ONAS was formerly SONEDE's Manager of Operations and, as such, had taken an active part in the setting up of SONEDE, which meant that the organization established for ONAS was similar to SONEDE's, at least in a first stage.

Many officers of SONEDE joined ONAS and the last two chairmen of SONEDE had occupied the same position in ONAS.

It could be said that there is complete symbiosis between the two institutions.

6.3.1.2 Program Coordination

In addition to commercial coordination which is systematic, SONEDE provides information on its own customers and network to ONAS, when the latter is planning new programs to cover small towns or peri-urban areas. The two utilities also collaborate on common training programs or cooperation projects abroad.

6.3.2 SONEDE - DGR Collaboration

Likewise, organic collaboration and program coordination exist between SONEDE and DGR.

6.3.2.1 Organic Collaboration

Such a collaboration is natural, since SONEDE is under the supervision of the Ministry of Agriculture in which the DGR is a General Directorate.

The head of DGR is also a member of SONEDE's Board of Directors. The Board often appoints the head of DGR to attend on its behalf meetings of the internal contract adjudicating committee.

6.3.2.2 Program Coordination

As previously indicated, the areas of responsibility of SONEDE and DGR were clearly identified in the Vth development plan which entrusts to SONEDE the supply of settlements of more than 250 people leaving those below this figure to DGR.

When Development Programs are formulated, the two agencies get together quite naturally to agree on who does what.

Another approach is adopted when DGR transfer to SONEDE responsibility for networks previously run by an AIC or DGR when the population concerned has reached an adequate socio-economic development level. All the required technical information is handed over to SONEDE to enable it to run the system properly.

6.3.3 Collaboration With Ministry Of Health

It is worth noting that the Ministry of Health, acting through its Environmental Hygiene Office, has responsibility for systematic control of drinking water and the quality of treatment plant wastes discharged into the sea and thus carries out efficient external control of the outputs of SONEDE and ONAS, in addition to the internal control of these two agencies. It also has a seat on the Boards of both.

A number of seminars have been organized by the Ministry of Health, in collaboration with WHO. They were attended by SONEDE, ONAS and DGR and the dialogue was particularly fruitful.

6.3.4 Weaknesses

The weak link of the chain is rural sanitation. At the present time, ONAS does not work in rural areas. A survey is planned by ONAS in collaboration with SONEDE to determine the impact of rural drinking water supply on public hygiene and sanitation with the aim of involving ONAS in the rural sector and consequently creating further areas of collaboration between SONEDE, ONAS, DGR and the Environmental Hygiene Office of the Ministry of Health.

7. Communities Participation in Water Supply and Sanitation Projects

7.1 Community participation, Iran

Iran's approaches are:

- Promotion of public participation for the urban and rural water supply and waste management.
- Education for promotion community knowledge for water conservation, pollution control, etc.
- Supporting private sectors in maintenance and operation of water and wastewater plans.
- Mobilize and facilitate the active involvement of women in water management teams.
- Sensitization of the public for the protection of water quality within the urban and rural environment.
- Control of industrial pollution sources to protect water resources.
- Development of sanitation management and wastewater projects.

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7.2 Awareness and Community Participation, Jordan

Quality control and assurance issues are closely related to accountability, responsibility, and reliability; issues that reflect general awareness, research and development status, and sophistication and level of implementation of legal codes and practices. In the last few years, there was a rapid increase in the quantity of water supply and sanitation services that was not paralleled with proper emphasis on associated issues such as training, preventive maintenance, availability of spare parts and materials, proper selection of treatment technologies, coordination of water and sanitary services in rural areas, and proper environmental impact assessment. There is a need for proper and standard procedures for analytical testing including proper QA/QC, proper reporting and documentation, skill certification, quality training and education, legislative improvements, institutional promotion system based on quality and merits supported with proper incentives, coordination of resources, and many other general improvements.

Primary health care programs offered by the Ministry of Health, international organizations, and local NGOs in rural areas involve components of proper hygiene and sanitation education. In addition, basic hygiene education is taught at schools. Approximately 35% of Jordan's population are school students. Education up to grade 9 is compulsory by law. Secondary school enrollment reached 64% in 1990 and the adult literacy rate reached 74.2% in the same year. Steps are underway to integrate basic water, pollution, and sanitation education as part of an overall environmental education curriculum to students in grades 1 to 10.

Students at the various universities in Jordan come from all backgrounds and corners of Jordan. Health education, water and sanitation, and environmental health education issues are offered by many departments, formally or informally, with project oriented water supply and sanitation being offered as part of the civil engineering curriculum at the undergraduate level. Public universities in Jordan have already graduated hundreds of engineers with proper sanitary engineering knowledge, many of whom participated in designing and supervising the construction of water supply and sanitation systems all over Jordan. In addition, the University of Jordan, offers a graduate degree in Environmental Engineering, with emphasis on sanitary engineering (drinking water, sanitary systems, and solid waste). In addition, industrial pollution, air pollution, surface and ground water pollution, soil pollution, and computer modeling issues are covered in the graduate program. Many of the department graduates are currently employees at the Water Authority of Jordan. Other departments, including agriculture, Medicine, and Science offer a broad range of environmental health education. In addition, there is a large number of community college in Jordan with health education being part of many discipline programs. Recently, private universities joined in contributing to the overall national educational and awareness efforts.

Television and/or radio systems are available almost in every Jordanian household ready for communicating hygiene and environmental health related messages. Newspapers, press conferences, seminars, volunteer groups, international organization in cooperation with local agencies are also contributing to raising the awareness level throughout rural and urban Jordan.

Before the recent introduction of Environmental Impact Assessment, there was no formal requirements for community participation programs to accompany national developmental projects, including water supply and sanitation planning and implementation projects.

However, general and informal community participation took place through the media and officials meetings with community representatives and other members. Elected officials in municipalities and local village council members are typical community representatives. Community participation is typically highest after the community feels the impact of developmental projects, mostly in the forms of complaints and discomfort.

In general, the recent expansion of sewerage systems to include most of Jordan's urban areas was driven mainly by the need to protect limited water resources from contamination, the inadequacy of the existing urban on-site sanitation systems, and the need for wastewater reuse. The sewerage systems matched, in general, the expectations and needs of urban population who generally have a relatively adequate access to educational, medical, training, cultural, and other services and facilities. In addition, public sewerage is less expensive and more reliable than urban on-site disposal methods which required frequent and expensive emptying. Water services, through house connections, have reached most of Jordan's household, however was not generally coordinated with providing proper sanitation facilities. The scarcity of water resources and the lack of reliability of traditional rural water supplies, such as seasonal springs and streams and rain catchment resulted in increased demands for public water supplies. The cost is however, a major factor for rural population, who generally used their traditional water supplies for irrigation purposes.

Health related international organizations operate to a large extent within local socio-political realities, but also local institutional realities. International health organizations should make their resources and services more accessible to the community.

7.3 Community Participation, Tunisia

Tunisia has a very old tradition in the management of water resources. In the thirteenth century, an agricultural engineer, Ibn Shubat, developed many centuries ago, a formula for sharing out water fairly between the fellahin of the oases of southern Tunisia: i.e. management of this resource was already a communal responsibility.

7.3.1 The AICs

It was against this background that the DGR initiated as early as 1987 a vast program aimed at having the farmers participate in the management of the water assets they use in common. This was the birth of AICs which are made up of water users managing their own water resources.

In fact, the role of the Government consists of providing the funds required to carry out the work necessary to mobilize these water resources, leaving it to the users to undertake the daily running of this asset.

This participative approach has the advantage of giving the farmer responsibility so that he becomes aware that the heavy investment made by the national community in order to make water available to him can only be optimized and preserved through rigorous management practices in which he is the leading actor.

An AIC is both a framework for the development of a feeling of responsibility and a unit which combines democratic practices and economic efficiency, as farmers are free to select the officers of their organization, and determine their management methods, the activities they wish to develop, and so on.

Even though the experiment is still relatively recent, as AICs were not formally incorporated until 1988, they already make up, in rural communities a network in the process of covering all hydraulic projects designed to meet the needs of farmers as well as drinking water supply objectives in the smaller rural settlements.

As at 14th July 1993, there were 1843 AICs of which 1294 were concerned with drinking water supply:

- 858 are fully operational
- 216 awaiting final approval
- 220 in the preparatory stage.

With respect to the creation of AICs, the main concern was efficiency, the major objective being to improve water distribution and quality in rural zones, and to establish at the local level a management system that ensures sustainability and proper operation of hydraulic infrastructure.

To achieve this, the program relies on human potential, on the ability of rural communities to take their destiny in hand. Thus it is the users who, brought together in their AIC, run their water system. This demonstrates that the involvement and proactive participation of community members in AIC activities are the program's fundamental principle and the key to its success.

At the local level, these organizations are responsible for the use and management of the hydraulic infrastructure that had been funded and constructed by Government Agencies.

Even before the AIC is formed, users are requested to help design their water system so that it is well adapted to the needs of the community. As soon as work is completed, the AIC looks after the maintenance and management of the system:

- Periodic preventive maintenance,
- Cleaning of the water well and its environs,
- Repair,
- Collection of charges,
- Hiring and payment of guards pumps operators, and
- Financial management.

A number of small businesses snowballed from the AICs': battery charging, irrigation spare parts.

AICs also promoted in a few communities the creation of Women's Interest Societies in which local girls get together and practise weaving, sowing, small livestock breeding, etc...

All these gatherings make it easy to arrange for public hygiene training.

The Government plays the part of initiator, coordinator and supporter of AICs, and is thus involved both upstream and downstream of the project.

Its goal is to make available to these rural organizations the means of their independence.

It provides financial and legal support for AICs and organizes a suitable training programs firstly for AIC members and staff (Chairman, accountant, members, pump operator) and secondly for government employees who will be called upon to help with the growth of these societies (Engineers, project designers, public health instructors).

The medium term goal of AICs is to assume full responsibility for the operations of water systems.

However the Ministry of Agriculture, the DGR and local divisions of the ministry still have to help AICs and provide support for their growth.

From its inception this program has received substantial support and assistance from German and US bilateral cooperation agencies.

Government support for AICs has many facets:

- Design and funding of water systems,
- Convincing rural communities that joining the project is beneficial,
- Completing legal procedures for newly created AICs,
- Program assessment and follow-up, and
- Training.

Seeing the high level of community participation achieved by existing AICs, the Government has decided to extend them nationwide: every time a new water point is established, an AIC is set up to run it.

7.3.2 The National Solidarity Fund (P.O. a/c no. 2626)

Another form of community participation appeared a year ago when the President of the Republic advocated the setting-up of a National Solidarity Fund after having visited a number of completely isolated rural settlements.

Donations by private individuals or corporations are paid into this Fund's Post Office a/c no. 2626.

In its first year, this fund collected 16 Million Tunisian Dinars. In addition it received a Government grant of 12 Million Tunisian Dinars.

Thus, it was able to provide assistance to 201 localities distributed throughout the country and to complete 101 projects by the end of November 1993.

This fund is managed by a committee consisting of representatives of the Presidency and the various Ministries concerned (Plan, Interior, Agriculture, Public Works, Health, Social Affairs).

Regional Government District Offices select the localities they feel most disadvantaged and forward applications for assistance to the above Committee: all the lacking facilities are made available, such as water, electricity, dispensary, school, rural road...

With respect to water supply, work performed covered 60 localities (140,000 inhabitants) for a total investment of 6.4 Million Tunisian Dinars.

An extensive appeal through all the media as well as posters was widely responded to by people from all layers of the national Community: 119,000 donators (66% of which gave less than 5 Tunisian Dinars).

The number 2626 became synonymous with National Solidarity.

Another facet of this Fund is helping create jobs locally in order to stop the inhabitants from moving away. The activities involved are livestock breeding, tree plantation, beekeeping etc..., for a total investment of 4.2 Million Tunisian Dinars. (1 Tunisian Dinar = 1 US \$).

7.4 Community Participation, Yemen

Because Urban Water Supply and Sewerage Systems which serve a large population it is not feasible to involve the communities in planning, design, construction and management of such systems. In the urban situation, people pay for the services provided to it.

In the rural areas, the communities through Local Development Councils (under the Ministry of Local Administration) have been involved for a long time in water supply. Often the communities themselves take the initiative and approach the authorities to ask for construction of water supply systems. At present all rural water supply systems are handed over to the communities after completion and the communities become responsible for operation, maintenance and financial management of the systems.

The policy for the future is to involve the rural communities from the very beginning of a project and to put capital cost sharing by the community as a precondition to all projects. This way, the communities will consider the water supply systems as their own and will be much more inclined to maintain them well.

8. Human Resources Development and Community Awareness and Strategies and Programs

8.1 Human resources Development, Iran

Iran's goals are:

- Creation and maintenance of a cadre of professionals and semi professionals for water and wastewater management.
- Development of training courses in the area of water and wastewater.

8.2 National Strategies and Plans, Jordan

The Department of Environment, in collaboration with the International Union for the Conservation of Nature and Water Resources, IUCN, formulated a National Environmental Strategy (NES), which was approved by the government in 1991. The NES put forward 5 strategies initiatives to be undertaken: constructing a legal framework for environmental management; institutional strengthening; an expanded role for Jordan's protected areas; bringing environment to people; and giving sectorial priority to water and population issues. In bringing environment to people, the NES recommends programs, including:

1. environmental and conservation education, through schools, literacy centers, clubs, community centers, media, vocational training institutions, colleges, and other centers.
2. involving the community in decision-making through an Environmental Impact Assessment process that includes mechanisms for public participation.
3. bringing environmental health awareness and services to local communities.

To solve water sector problems, the NES recommended actions relating to institutional organization, information, research and development, planning, impact assessment, specifications, legislation, awareness and public participation, rationalizing consumption, and international relations.

In addition to the continuous efforts to explore new water resources and maximize the use of Jordan's renewable water budget, the great priority dedicated by Jordan to meet water demands resulted in introducing management and optimization techniques which include:

1. protection of water resources from contamination;
2. reduction of losses from water supply networks;
3. improvements of irrigation efficiency and crop yields;
4. reuse of treated wastewater in irrigation and industries;
5. improvements in House-water use efficiency; and
6. negotiation of a regional approach to water resources sharing.

The management and optimization techniques discussed above are being translated to specific programs and projects by The Water Authority of Jordan along the following lines:

1. reduction of groundwater over-pumping by approximately 30% during the current decade by investigating the feasibility of brackish water desalination, constructing new dams, and expanding water harvesting activities;
2. upgrading and expanding the capacity of existing WWTPs by approximately 50% over the current decade and expanding the existing sewage collection networks;
3. improving the efficiency of water supply networks to reduce loss and waste; and
4. improving the efficiency of irrigation methods to achieve a reduction of irrigation water use per unit area by approximately 10% over the current decade.

The Ministry of Health plans to improve and upgrade regulations related to water and sanitation in a way that permits the Ministry to have closer control over water quality and potable use. The Ministry intends to increase the number of its employees on water and sanitation monitoring, continue to train its staff in the same field, expand its laboratory services to all areas not currently serviced properly, and train its medical staff to carry out water and sanitation monitoring.

The movement of people from rural to urban areas is a serious issue in Jordan. In 1991, 77.9% of the population was urban. The NES calls for creating population balance through creating investment and public service opportunities in rural areas to achieve reversal of immigration.

See also sec. 7.2.

8.3 Human Resources Development, Tunisia

The development of human resources through training and hiring of a large number of water and sanitation skilled personnel has been a major concern of the government ever since the earliest Economic Development Plans.

It was essential to train an adequate number of engineers and technicians so as to permit efficient planning and management of water supply and sanitation at the national, regional and local levels.

In addition to the Technical Secondary Schools that provide training for technicians, it was decided soon after independence, to set up new Technical Institutes and Engineering Schools so as to be able to deal with various issues related to Drinking Water Supply: Hydraulics, Civil, Mechanical, Electro-technical, Engineering, etc...

Furthermore, special care was devoted to the setting up of SONEDE and, later, ONAS through a rational recruitment policy and attractive compensation for their personnel.

We are now going to turn to human resources development at SONEDE and ONAS and give details of SONEDE's training programs.

8.3.1 Human Resources Development at SONEDE

The initial staff comprised largely ex-RDE personnel, so there was some need to revise patterns of thinking to fit a market-led entity. SONEDE found itself understaffed at the technical and managerial levels and overstaffed at the lower levels (out of its total staff of some 1,800 some 300 were in excess of needs). To enable management to cope simultaneously with a large works program and the launching of a new organization, technical consultants and a management adviser were introduced; management consultants installed a commercial accounting system and trained staff in its operation; and an external audit was inaugurated.

Initially, progress was uneven; the staffing imbalance was difficult to rectify, delays in introducing adequate salary scales caused some loss of morale, and problems with engineer recruitment and new procedures created, for a time, a serious risk of losing control of project expenditures. Gradually, however, SONEDE settled down. Expatriate engineers from France helped overcome the engineering problems; new divisions for statistics, organization and methods, cost-accounting and internal audit began to aid in improving performance; billing and collection were streamlined; and training courses were introduced. Satisfactory conditions of employment have gradually produced a contented, dedicated and performance-oriented staff.

SONEDE has achieved a growing degree of maturity over the years. It was able to dispense with engineering consultants entirely for the Fifth Water Supply Project. It had already conducted engineering studies for smaller settlements for which it had become newly responsible in 1973. Since 1974 it carried out competent tariff studies. Under the fifth project, SONEDE was judged capable of executing a major study of service level goals for the sector, in the light of rising marginal cost, and of the financial policy options for attaining them, including questions of cost recovery, consumer ability to pay, system maintenance, taxation and government contribution levels. Finally, SONEDE has provided technical assistance to Arab and African countries.

8.3.1.1 Manpower Development in Operations

SONEDE's personnel in 1991 numbered about 4,800, i.e., about 5 per 1000 connections compared with about 18 per 1000 in 1968. Recruitment has been facilitated by the quality of the national educational system, by SONEDE's reputation as a well-managed and expanding enterprise and by a comprehensive staff benefits package introduced in 1972 and 1984; staff shortages have long been eliminated, as has the earlier overstaffing in certain categories. A system of initial probation has been introduced. In collaboration with the Government's Department of Employment and Professional Training, SONEDE maintains a continuous training program for its technical personnel; it also sends engineers overseas on training scholarships and arranges regular in-house seminars and short training programs. These arrangements appear to be adequate and appropriate.

8.3.2 Human Resources Development at ONAS

SONEDE's success was undoubtedly a factor in the decision to establish a similar body for the sewerage sub-sector. A separate authority was considered necessary, in view of the very considerable backlog in the development of sewer services. ONAS was established in 1974 and began

operations in 1975. Its Articles of Association is broadly similar to SONEDE's and it has comparable conditions of service for its staff. However, unlike SONEDE, it depends for about half of its revenues on operational subsidies from the government.

ONAS was also heavily dependent on consultants in its early years, when it was faced with the task of launching a major works program and simultaneously taking over, one by one, existing systems and staff from a number of different municipal authorities. At that time, a lack of experienced senior staff produced serious problems; top management became submerged in detail; project planning and control were weak; and accounting and financial control systems became dangerously defective. Drastic measures were indicated; staffing was strengthened, the Finance Department was extensively reorganized and consultants were attached as advisers to introduce a proper system of project planning and control.

ONAS had 2,500 staff, in 1991 all Tunisian. Faced at the outset with the problem that sewerage and sewage disposal require specific technical knowledge which was somewhat lacking in Tunisia, ONAS has made a major effort in training. Shortly after its formation, training needs were assessed in detail and a training master plan was formulated in 1978. At the same time, a Training and Professional Development Commission was created in ONAS to draw up training programs, establish priorities and a timetable, and select the modes of training to be pursued. Once these activities were launched, the commission would supervise their execution and evaluate the results. A program of study visits to sewerage authorities in foreign countries was also launched, organized with the help of external financing agencies and also of contractors, who were required to allow for such training in their bids.

ONAS attaches equal importance to on-the-job training; every supervisor is charged with training his subordinates, and ONAS believes this has been the essential element in establishing an effective sewage treatment system. However, there are still some staff shortages at the technician level, both in number and in quality.

8.3.3 Training at SONEDE

8.3.3.1 First Training Program

Specialists in manpower training always maintained that the proper approach to training is to prepare a master plan. This is achieved by starting out with comprehensive questionnaires. A qualified central body starts analyzing these questionnaires to define the national needs of the various categories at different levels. After a thorough analysis by experts, a training objective and programmes are identified and finally a training master plan is prepared. This is not the end of the story. There remains the challenging stage relating to the actual implementation of the master plan. This involves securing the appropriate trainers, educational means and training facilities.

The above methodology assumes that there are no difficulties or obstacles in collecting information, securing experts for analysis, obtaining trainers easily and other education and training facilities.

It is obvious that the above basic prerequisites are not available in developing countries:

- People who are required to fill out the questionnaires are often illiterate;
- Non-availability of staff capable of preparing the format of the questionnaire from the first, to be able to analyze them after they are completed. The limited number of qualified staff are fully occupied in operating the installations.

With these major bottlenecks, SONEDE developed a system which may seem modest, but is nevertheless the most practical way of achieving the objective and easy to apply in developing countries. First it was noticed that the so-called "skilled laborer" does his job in a traditional routine manner. Even the injection of newly recruited trained laborers did improve the performance of the old group for a time, it caused conflicts between the two groups. As a result the job was not done adequately. For example, the plumbers and fitters had to do the same job more than once to achieve the required standard. Having noticed this defect in plumbers and fitters, attention and effort focussed on improving their performance through appropriate training. At this stage, only this category was considered for training to avoid diluting limited capacity.

The following procedure was followed:

- Identification of prospective trainers from among experienced staff;
- Searching for an organization that has training facilities. This was found in the National Office for Vocational Training;
- Modifying their ongoing internal plumbing training programme to suit our needs;
- Initiating the first training session which was run by the trainer from the National Office and with a contribution from SONEDE's prospective trainer; and
- After completion of the first training programme the job could then be done independently by SONEDE's own trainers.

Other programmes were developed for remaining staff categories in a similar manner. However, some of these programmes required the use of the facilities available at the National Office such as workshops for mechanics, electricians, drivers etc... To this end, a healthy cooperation was established with the National Office. This resulted in the organization of 14 different training sessions, out of which 7 were conducted in collaboration with the National Office.

8.3.3.2 Goals and Achievements

The various training programs developed by SONEDE are designed to achieve the following basic objectives goals:

- Raise the administrative and technical skills of staff and labor and enable them to keep up with the progress of work and administrative management procedures;

- Assess un-exploited potential in a rational manner so as to make it possible to upgrade the personnel concerned;
- Provide further training for certain trades through modules covering areas specific to SONEDE (hydrology, corrosion, cathodic protection, optimization of network management, decontamination of drinking water etc...);
- Provide training courses to better adapt participants to their specific jobs;
- Provide retraining for employees who are to move on to new jobs or to different jobs from those they held; and
- Organize short-term training leading to credits.

In 1992, 849 employees from various job strata received training, either in-house or through Tunisian or foreign training firms.

The table below shows the rise in the number of employees trained since the setting-up of SONEDE's training center in 1977:

Table - 23: (4)

Year	1977	1988	1992
Budget TD 1000	52	130	238
Employees trained	158	587	818
Percent growth	6	13	16

8.4 Human Resources Development, Yemen

The National Water Supply and Sanitation Authority, General Authority for Rural Water Supply and Electricity and the other institutions involved in the water and sanitation sector have programmes for technical and managerial training of staff.

Urban water systems enjoy a higher degree of reliability than rural systems due to the availability of better trained personal in charge of operations and maintenance.

The General Authority for Rural Electricity and Water has a training programme of rural water supply operators assisting communities to operate, maintain and manage the water supply installations.

9. Suggestions and Recommendations

9.1 Jordan's Recommendations

9.1.1 Water Supply Recommendations

1. The current water treatment programs should be evaluated to assess their appropriateness and sustainability in terms of providing adequate safeguards against variable water quality, and potential contamination, in addition to identifying training, operation, and maintenance requirements.
2. The economic and health impacts of existing water distribution systems should be evaluated in terms of operating conditions, maintenance requirements, contamination potential and corresponding health effects. Factors such as periods of interrupted pumping and loss of pressure should be included in the evaluation. The results should be used to select alternatives that provide long term feasibility in terms of health and cost benefits.
3. The Water Authority and The Ministry of Health should collaborate closely for proper QA/QC. QA/QC procedures should accompany all reported monitoring data.
4. There is a need for proper and creative integration of research and development in planning community water supply and sanitation programs.
5. Appropriate mechanisms should be established to integrate community participation into decision making on issues related to the development of appropriate local water supply programs.
6. To conserve water and reduce cost of services, efforts should be made to encourage the appropriate use of house-hold water supply systems in rural areas for non-potable purposes, such as gardening and live stock watering. Such efforts should be accompanied with appropriate awareness programs, and proper financial and technical assistance.

9.1.2 Sanitation recommendations

1. Study current wastewater treatment systems to evaluate their appropriateness in terms of costs and effectiveness, in addition to identifying training, operation, and maintenance requirements.
2. Evaluate existing wastewater effluent disinfection practices and test and implement appropriate technologies to ensure proper removal of pathogens.
3. Conduct field studies to determine rural needs and requirements, in terms of water supply and sanitation services. Such studies should rely on public participation, especially that of women and community leaders.
4. In addition to providing national potable water supplies and urban sewerage services, The Water Authority should expand its functions, in coordination with other concerned organizations, to provide appropriate water and sanitation services to rural areas.

0616

Methods for the concentration and detection of human enteric viruses in shellfish: a review

Bouchriti, N; Goyal-SM

Microbiologica (Bologna); 1993; Vol. 16, No. 1, pp. 105-114
 Subjects: Aquatic animals; Enteroviruses; Seafood

Shellfish, including oysters, mussels, and clams, are filter feeding bivalve mollusks and can accumulate human pathogens at levels higher than those in their surrounding waters. Outbreaks of shellfish-borne enteric viral diseases have been reported worldwide. To determine the public health safety of shellfish, methods are available for the direct detection of human enteric viruses in shellfish tissues. Potential problems with these methods include (i) toxicity of the final sample to cell cultures used for viral assay, and (ii) a large sample volume that cannot be conveniently assayed. To overcome these problems, several methods for the concentration and detection of enteric viruses in shellfish tissues have been developed and utilized. A review of these methods indicates that none of them is universally accepted because no single method is equally effective for shellfish obtained from different geographical locations and under all conditions. It is suggested, therefore, that a proposed method should first be tested under experimental conditions, utilizing virus-spiked shellfish, before using it under field conditions.

0636

The microbiological contamination of an oyster growing area in Morocco: the Qualidia Lagoon

Bouchriti, N; Marrakchi, A; El Fahim, A

Hydroecol. Appl.; 1992; Vol. 4, No. 2, pp. 189-202
 Subjects: Seawater; Bacteria; Bivalves

A 3-year bacteriological survey of an oyster growing area in Morocco, where the Japanese oyster (*Crassostrea gigas*) is grown showed that the contamination had a tendency to increase from winter to summer. The contamination of the lagoon was not continuous but intermittent. Animal manure and human recreational activities in the vicinity of oyster growing areas were important sources of pollution. Other sources of minor importance such as the installation of spats and traditional fishing activity contribute also to the contamination of the lagoon. The major source of pollution was from animal origin except during the summer when human contamination prevailed. Oysters harvested from this lagunar ecosystem contain fecal bacteria and may also contain bacterial pathogens. Thus, they may present a public health hazard and especially so in summer. It is hence advisable to rely oysters in clean waters or depurate them before marketing. Some control may also have to be placed on the use of the lagoon for human recreational activities to reduce the contamination during summer.

0615

Aeromonas species in stabilization ponds in the arid region of Marrakesh, Morocco, and relation to fecal-pollution and climatic factors

Boussaid, A; Baleux, B; Hassani, L; Lesne, J

Microb. Ecol.; 1991; Vol. 21, No. 1, pp. 11-20
 Subjects: Irrigation; Oxidation ponds; Faecal pollution; Arid zones

Fecal coliforms, temperature, and chemical oxygen demand were measured simultaneously with *Aeromonas* species densities. Statistical methods were utilized to analyze the significance of average differences and temporal patterns of *Aeromonas* species numbers. Removal of *Aeromonas* in the whole system did not exceed 1.14 log. *Aeromonas* densities showed significantly higher resistance to the treatment process when compared with fecal coliforms; however, abundance of the two groups presented a similar seasonal change. The highest numbers occurred during the cold months, while the lowest appeared in the warm months. These temporal changes were simultaneously observed in all the stations investigated and were negatively correlated with water temperature values. *A. sobria* dominated all the final effluent samples. This greater survival of *A. sobria* and its known pathogenicity may limit the re-use of treated water for irrigation of fodder plants.

0220

Metal exchanges in the fauna sediment system: the case of nereis diversicolor and scrobicularia plana in the Bou Regreg Estuary (Morocco)

Cheggour, M.; Texier, H.; Moguedet, G.; Elkaim, B.

Hydrobiologia HYDRB8; November 22, 1990; Vol. 207, p 209-219 (6 fig, 3 tab, 20 ref.)
 Subjects: Estuaries; Metals; Aquatic animals

The types and quantities of metals retained by *Nereis diversicolor* and *Scrobicularia plana*, two species selected as bioindicators, are investigated in a predominantly arid estuary environment. Certain abiotic parameters and a number of physiological processes linked to metabolic and reproductive functions play a decisive role in the seasonal influence of metal levels on the tissues of these organisms. Given the depositoric diet of these organisms, the sedimentary bed would appear to be the principal source of metal accumulation. Zinc accumulated heavily and greater in *Nereis* than in *Scrobicularia*. Noticeable accumulation of copper, nickel and chromium, in the order CuNi=Cr was observed in *Scrobicularia* more than in *Nereis*. Lesser accumulation of lead and manganese, in the order PbMn, was equal in both genera. Light accumulation of vanadium and iron (VFe) was seen more in *Scrobicularia* than in *Nereis*. The possibility that these metals may be carried into the estuary by sewage water from the cities of Rabat and Sale should certainly not be ignored.

5. An evaluation should be carried out to determine the impacts of providing house water services for rural communities, including such factors as: increased potable water consumption, increased wastewater generation, general satisfaction, and costs of public services. In addition, the impact of providing house water services on existing local on-site waste disposal practices should be evaluated and appropriate actions taken to bring the level of sanitation services to that of water services.
6. An evaluation of existing wastewater collection networks should be carried out to determine the appropriateness of design and construction practices used in conveying locally produced wastes. The evaluation should identify the most effective and appropriate practices, and generate locally applicable data. Such evaluations should follow scientific procedures and provide specific engineering and technical data, rather than observation reports and statistical analysis.
7. Appropriate, on-site sanitation technologies should be developed for rural application. Research and development activities may include modifications of existing technologies using locally available skills and materials, developing new and improved sanitation technologies, and issuing proper design and construction codes and specifications.
8. The data and technologies presented in this report may be used for providing general guidelines for local planning and evaluation of water supply and sanitation programs. Specific design data are not included because such data are not locally available. Design and evaluation procedures are available in many specialized references. The selection of appropriate technologies should be based on the specific requirements of individual projects.

9.2 Suggestions, Recommendations, Tunisia

In view of the preceding, it can be said that Tunisia has devoted a major effort to resolving the Rural Water Problem. However an assessment of the situation enables us to conclude that the results achieved are not commensurate with the means used. The delay recorded in the progress of most projects makes us realize that the solution to the problem is not solely a matter of financial resources and that there are other constraints and difficulties that hamper the achievement of the goals.

9.2.1 Constraints and Difficulties

A distinction can be made between the difficulties that are unavoidable for operators such as natural, demographic or technical data and those that are related to project selection design and management.

9.2.1.1 Constraints

- Natural: the type of terrain in rural areas makes the supply of water more difficult particularly in the south and the center of the country. In addition, and sometimes even in the regions to which access is easy, hydraulic resources are still either insufficiently known or inadequate in volume or in quality.

- Demographic: the scattered nature of the rural population is the main obstacle to any rural water supply and sanitation because of its impact on project costs.
- Technical: as imposed by lending institutions, the ceiling for investment costs per head of population is not adapted to the scattered feature of rural population.

9.2.1.2 Difficulties

These difficulties are encountered at all project phases from identification up to completion and operation:

- Lack of overall strategy in the planning of rural drinking water and sanitation. The demarcation difficulties between rural and urban water supply, on the one hand, and the low level of coordination between water and sanitation activities on the other, make it even more difficult to achieve proper planning or have a good overview of the problems.
- Implementation: this is related essentially to the small number of skilled and experienced contractors in this field which are willing to work in rural areas. The slowness and complexity of contract award and payment procedures also have an effect on the progress of work on projects.
- Interim projects: social or political pressures often force the Ministry of Agriculture's local agencies to drill wells and operate them with limited means. These are considered interim projects awaiting their being taken over by SONEDE. This approach, in addition to the fact that it leads to the implementation of medium quality projects, is the source of additional reworking and renovation expenses when they are transferred to SONEDE.
- Institutional: all the difficulties listed above are often aggravated by an institutional vacuum, particularly at the regional level, especially with regard to management and operation. There is no regional body that groups together the various departments concerned by rural water and sanitation.

In view of all these difficulties and of the importance of the sector, a number of recommendations come to mind in order to ensure better management of the rural water supply and sanitation sector.

9.2.2 Recommendations

1. The implementation of strategies on rural drinking water supply and sanitation is closely related to the policies adopted for regional development. It is imperative that it be integrated within an overall plan.

Such a plan should not restrict itself to the setting of a budget but rather consist of a sectorial strategy that would identify both the goals to be achieved and the resources to be used.

It would be even more efficient to integrate all the projects within a national plan for the sector which could overlap a number of development plans.

2. Water project identification is more successful when it is made at the regional level where people are generally closer to local realities and priorities. However, identification should not be a one off event when a plan or a budget is being formulated, or when seeking external finance, it should rather be part of a regional master plan.
3. In view of the implications of water for all the economic and social aspects, the criteria for evaluation should take into consideration the specific nature of this sector. Considerations of profitability or investment cost per head of population should not be the determining criteria for the assessment of projects in rural areas. These should rather be evaluated on the basis of their contribution to the achievement of qualitative (health development etc..) goals.

Eligibility criteria for projects to be current implementation in rural areas should be consistent in order to avoid the current differences between similar projects, while adjusting the criteria to the needs of scattered populations.

4. Project implementation: during implementation due care should be given to a cost control, optimal use of local capabilities as well as to the integration of the water sanitation and health education components.

On the other hand, it is strongly recommended to use appropriate technologies likely to facilitate the employment of local labor as well as to look into the possible adoption of renewable energies.

5. Maintenance and operation problems: absolute priority should be given to resolving these problems. There is a definite need to develop periodic maintenance and overhaul programs for the systems and networks, instead of waiting for breakdowns.

9.2.3 Conclusions

- Attention should be focussed on the magnitude of the needs and problems in rural areas, with special emphasis on scattered populations.
- It should be realized that financial resources are not the main hindrance to the achievement of goals.
- Coordination of overall planning and clear identification of functions in the areas of operation and maintenance are preliminary requirements for better management of this sector.
- Community participation through the creation of AICs should be strongly encouraged.

9.3 Yemen Recommendations

9.3.1 Water Supply

- a) Develop and improve water resources to conserve groundwaters.
- b) Implement education programs concerning the protection of water resources from all types of pollution.
- c) Construct dams and water structures to store run off water.

9.3.2 Sanitation

- a) Needs urgent actions to establish institution or authority to deal with rural sanitation.
- b) Adopt appropriate sanitation systems for different rural areas.
- c) Perform education programmes to improve the awareness of people.

9.4 General Recommendations

1. Specific water, sanitation, health, and population programs should be planned and implemented.
2. Community participation should be made to play an effective role in developing, improving, and upgrading rural sanitation systems.
3. To enhance existing rural health conditions related to water supply and sanitation, additional and specific health training, and awareness programs should be directed towards school students and women, especially house wives and mothers, through schools, community centers, literacy centers, and medical centers. Volunteer groups involved in health education and community awareness, especially those reaching women and children, should be encouraged. School teachers, community leaders, and health workers should be trained and educated on sanitary programs. Training can be provided by institutions of higher education, international organizations, and government training agencies. Awareness and education programs can be greatly enhanced by the media.
4. Health and rural water supply and sanitation organizations require strengthening, including providing adequate staffing and training, funding, distribution of responsibilities, introducing coordination mechanisms, and allocating adequate authorities. The establishment of an independent rural water and sanitation sub-authority that coordinate efforts and resources among all related institutions.
5. Research and development should be integrated as part of water supply and sanitation planning. All research and development phases should be given appropriate attention including basic research and testing, technology transfer, and technology development and application. The role of research and development institutions should be activated and appropriate funding and incentives be provided. Bridges between research and education institutions and the various sectors of the society should be built and strengthened through education, planning, and trust building mechanisms.

6. International organizations should direct appropriate efforts to enhance rural health, including providing training, technical assistance, awareness programs, and economical assistance. Local villages community leaders, school teachers, women groups, health workers, and other community members should be included in educational, awareness, and training programs offered by international organizations.
7. In-depth, field evaluation of rural water supply and sanitation condition should be carried out to assess the needs and provide specific recommendations for developmental planning. Such studies should include local community leaders and members, and should emphasize community participation, especially that of women.
8. The development of appropriate technologies that utilize local materials and skills, and are based on local experience and requirements is essential. Specifically planned and coordinated programs, supported with appropriate funding, should be planned and implemented.
9. Developmental projects that depend on foreign technologies should be accompanied with appropriate hands-on training programs, maintenance programs, QA/QC programs, preventive maintenance programs, enactment of proper legislation, and appropriate attention to community participation.
10. There is an urgent need to formulate and enact appropriate legal initiatives to deal with the demands of modern development and technologies, protect the environment, define QA/QC procedures, delegate and coordinate resources, specify enforcement mechanisms, provide mechanisms for assigning responsibilities and appropriate liabilities, allocates appropriate funding and resources, and reflect local requirements through community participation.
11. There is a clear need to develop local sanitary design criteria and data, and to upgrade existing engineering codes. Updating such codes requires activation of local research and development institutions.

10. Bibliography

10.1 Iran's References

1. Environmental Health Department Reports of activities. (1989-1994)
2. Reports received from province's E.H sections (1993).
3. Technical reports, Municipality of Tehran (1992-1993).
4. Report on water supply and sanitation in Iran (Alaie, Mahmoodian) - 1993.
5. Hydrology, (Dr Joneidi, Iran) 1990.
6. Reports of urban water and wastewater affairs, Ministry of Energy (1992-1993).

10.2 Jordan's References

1. The Hashemite Kingdom of Jordan, Jordan Country Report to the United Nations Conference on Environment and Development (UNCED). Brazil, June, 1992.
2. The Hashemite Kingdom of Jordan Department of Statistics, Statistical YearBook. Number 42, 1991.
3. World Health Organization, Eastern Mediterranean Regional Office, International Drinking Water Supply and Sanitation Decade-Sector Profile for Jordan. Alexandria, 1990.
4. The Hashemite Kingdom of Jordan, Ministry of Water and Irrigation, The Water Authority of Jordan. 1991 Annual Report. 1991.
5. Mohammed Iafi, The Water Authority of Jordan, Achievements of The Water Authority Report. The National Experts Meeting to Asses the Achievements of the International Decade for Water Supply and Sanitation (1981-1990) held in Amman, April 4 and 5, 1993, April, 1993.
6. Hussein Al-Khandaq, Ministry of Health, The Achievements of The Ministry of Health. The National Experts Meeting to Asses the Achievements of the International Decade for Water Supply and Sanitation (1981-1990) held in Amman, April 4 and 5, 1993.
7. Ministry of Municipalities, Rural Affairs, and Environment, National Environmental Strategy, approved 1991.
8. Raja Jadoun, The Water Authority of Jordan, The Environmental Dimension of the Tasks of The Water Authority-Programs and Strategies. Presented at the National Meeting on The Environment in Jordan, Between the Positives and the Negatives, Jordan Engineers Association, December 23, 1992.
9. Ministry of Public Works and Housing, Sanitation Code for Buildings, First Edition, Volume 19, 1988.
10. Kalbermatten, J. M., et al., Appropriate Technology for Water Supply and Sanitation-A Planner's Guide, The World Bank, 1990.

11. Eli Dahi (ed.), Environmental Engineering in Developing Countries. Center for Developing Countries, Technical University of Denmark, Publisher: Polyteknisk Forlag, 1990.
12. Task Force on Natural Systems, Natural Systems for Wastewater Treatment. Manual of Practice FD-16, Water Pollution Control Federation, 1990.
13. Metcalf and Eddy, Inc., Wastewater Engineering-Treatment, Disposal, and Reuse. Third Edition., McGraw-Hill, Inc., 1991.

10.3 Tunisia's Bibliography

- Alimentation enEau Potable des Zones Rural: Ministere de l'Agriculture - SONEDE. Aout 82
- Etude de la strategie en Matiere d'Alimentation en Eau Potable des Zones Rural - SONEDE. Octobre 1986.
- Alimentation enEau Potable et Assainissement des Zones Rural: (Project PNUD.OMS N TUN. 84.001.A.0114) Etude de Synthesis par M.BENAICHA Juin 1988.
- Rapport Annuel d'Exploitation de l'ONAS pour l'annee 1988.
- Evaluation de la strategie: Sante 2000: Ministere de la Sante Publique Janvier 1991.
- Eau Potable dans le VIII plan 92-96 SONEDE Octobre 1991.
- Project des institutions d'Eau Potable en Milieu Rural. Tunisie centrale 1986-1991 (Project USAID N 6640337): Rapport: Institute for Development Authopology. Janvier 1992.
- Situation et Programme du Secteur de l'eau Potable. SONEDE Fevrier 1992.
- Desserte en Eau Potable par la SONEDE. Juillet 1992.
- Les Stations d'Epuration des Eaux Usees en Tunisie. ONAS Mars 1993.
- Rapport d'activites de la SONEDE pour l'annee 1992. SONEDE Avril 1993.
- L'Assainissement Individuel: ONAS.
- Les AIC: Ministere de l'Agriculture

10.4 Yemen's References

1. Appropriate technology for water supply and sanitation. A sanitation field manual by John M. Kalbermatten, Dean. S. Julius and Charles G. Gunnerson.
2. A guide to the development of on-site sanitation. R. Francis, J. Pickford and R. Reed. WHO Geneva.
3. A Handbook of gravity - flow water systems. Thomas D. Jordan Jr.
4. Environmental engineering in developing countries edited by Eli Dahi. Technical University of Denmark.
5. Davey and Lightbody's
The control of disease in the Tropics.
by H. K. Lewis and Co. Ltd. London

References:

- (1) CEHA, "Terms of Reference for CEHA Special Studies", CEHA, Amman, Jordan, 1992.
- (2) "Appropriate Technologies for Water Supply and Sanitation", by Eng. M. Alaie and Eng. Seirafianpoor, Ministry of Health, Tehran, Iran, 1993.
- (3) "Appropriate Technology for Water Supply and Sanitation for Jordan", by Dr Abdullah Shanableh, University of Jordan, Amman, Jordan, 1993.
- (4) "Appropriate Technology for Water Supply and Sanitation in Tunisia", by M. Benaichia, Tunisia, 1993.
- (5) "Appropriate Technology for Water Supply and Sanitation in Rural and Peri-Urban Areas", by Eng. A. Al-Kumari, Sana'a, Yemen, 1993.