Water Supply, Sanitation and Health
in
the West Bank

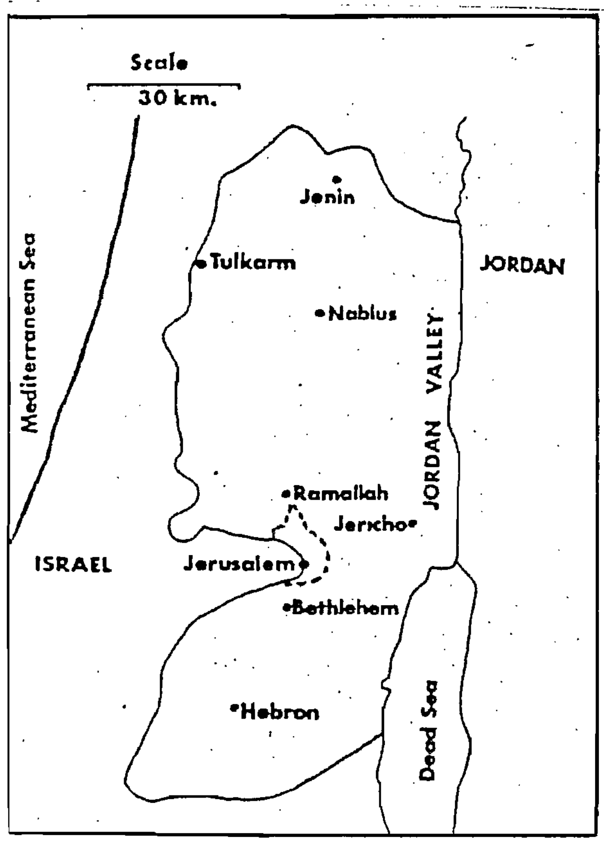
Chris Smith

1987

Table of Contents

1. Introduction

Figure 1. The West Bank



1981 - 1990 has been declared the "International Drinking-Water and Sanitation Decade" by the United Nations. The aim of the Decade is the promotion of safe drinking-water and adequate sanitation for the world's population. This paper will discuss some of the issues relating to the promotion of water supply and sanitation in the West Bank, with particular reference to health issues. It is intended as a contribution to the development of locally appropriate models for water supply and sanitation promotion, through which the health benefits of these facilities can be maximised.

The paper reviews existing information on water supply, water quality and sanitation in the West Bank, and discusses some of the issues concerning the relationship between these facilities and the health of the population. The health impact of water supply and sanitation facilities has been one of the underlying themes of the Decade: this paper is a preliminary attempt to relate these discussions to the West Bank context.

Water supply for the agricultural sector of the West Bank is beyond the scope of this paper and has been discussed elsewhere (1).

2. Water Sources

Four main types of water sources are utilised in the West Bank for drinking purposes: piped municipal supplies, rainfed cisterns, springs and canals. Exact data concerning the number of inhabitants served by each type are not available. The Israeli Central Bureau of Statistics estimated that in 1981, 65% of West Bank households were supplied with running water, 25% were using household rainfed cisterns, and 9% communal sources (springs or canals) (2). These data do not include the population of East Jerusalem.

Table 1 presents these data divided by town and village, showing that an estimated 92% of town households had running water, compared to 50% of rural households.

Table 1. West Bank Household Water Supply by Locality (1981)

	Percentage		
	Villages	Towns	Total
Running Water in Dwelling	29	79	45
Tap in Courtyard	20	13	20
Cistern in Courtyard	38	6	25
Communal Source	13	2	9

Source: Central Bureau of Statistics (3).

Another source of data concerning rural water supply, distributed by the Jerusalem Pontifical Mission in 1983, is summarised in Table 2. According to this report, 71% of West Bank villages were without a piped supply in 1983.

The data in Table 2 do not contradict the Israeli estimates, as Table 2 refers to villages and Table 1 to households. Larger villages tend to be connected to the water grid before smaller

Table 2. West Bank Villages Without a Piped Water Supply (1983)

Region	Total Number of Villages	Villages Without Piped Water	% of Villages Without Piped Water
Jerusalem	32	18	56
Bethlehem	33	20	61
Hebron	60	40	67
Ramallah	70	37	53
Nablus	124	112	90
Tulkarem	46	31	67
Jenin	64	47	73
TOTAL	429	305	71

Source: Pontifical Mission for Palestine (4).

ones, thus a figure of 50% of households without a piped supply may correspond to 71% of villages without a piped supply (Table 2).

2.1 Piped Water

All of the major towns and about 30% of the villages of the West Bank are supplied by piped water systems. Water systems are administered in the Bethlehem, Jerusalem, and Ramallah areas by semi-independent "water undertakings" and in other regions by the Israeli-controlled municipalities. All networks are supplied from deep tubewells, and water is, in theory, chlorinated.

Table 3 shows Government Health Department figures for per capita water consumption in 1980, in selected areas of the West Bank. In comparison, an average per capita consumption for Western Europe is about 120 litres/capita/day (5). The government figures should be treated with caution, as it is not clear whether allowance for leakage has been made in the calculations. They are also mainly for cities, and not for rural areas, where the cost of piped water may be more of a constraint on use. Nevertheless, it is probable that water consumption, where household connections are provided, is in the range 50 - 100 litres/capita/day.

Table 3. Reported Average Public Drinking Water Consumption in Selected Areas of the West Bank (1980) (Litres/capita/day)

Region	Consumption (l/ca./day)
Hebron	70
Jericho	70
Bethlehem	108
Ramallah	81
Tulkarem	176
Qalqilia	135
Salfit	46
Jenin	108
Tubas	86
'Anabta	51

Source: Calculated from Adler, Y. et. al. (6).

2.2 Rainfed Cisterns

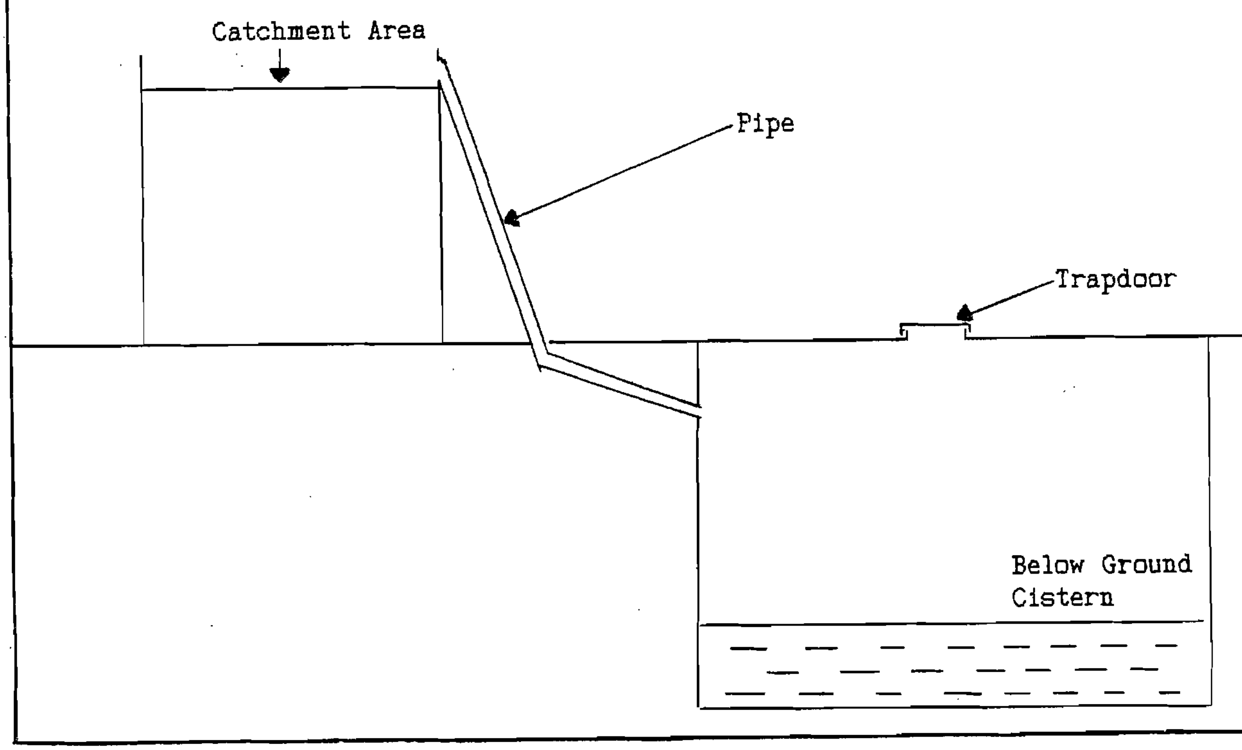
Rainfed cisterns are the main drinking-water source for households without a piped supply. In some areas they remain a preferred drinking-water source, even when a piped supply has been installed. The taste of the cool cistern water may be preferred to the warm, chlorinated, and sometimes slightly saline municipal supply. Cistern water also lathers better for washing.

Cisterns may be fed from various kinds of catchments including rooftops, backyards, or other land surfaces. The vast majority of cisterns are below ground, either cement-lined or dug directly into impermeable rock.

Figure 2 shows the main elements of a rooftop catchment cistern system.

Water is channelled from the catchment to the cistern via pipes or open channels. In either case, it is normal practice not to collect the first flush of rainwater after a dry spell, in order to avoid the washing of accumulated dirt from the catchment into the cistern. Various kinds of cloth and fibre filters are often

Figure 2. Main Elements in the Rainfed Cistern Collection System



used to strain solids from the collected water. In larger systems gravel filters are sometimes used.

Two main methods of water removal from cisterns are used:

a. Water may be removed by a bucket which is lowered into the cistern through a trapdoor in the roof using a rope or chain. The bucket is usually either plastic or metal, and is often stored hooked onto the underside of the cistern trapdoor for reasons of hygiene and convenience.

b. In villages with electricity, small electric pumps are used to pump water from the cistern to a storage tank above ground. The tank usually supplies a house or courtyard tap.

Hand-operated pumps used to be used for water removal, but these are now relatively rare.

When a household changes from bucket removal to pump removal, the water consumption of the house will tend to increase, leading to a higher risk of summer water shortages.

The supply per capita provided by a rainfed cistern depends on the catchment area, the rainfall, the storage capacity of the cistern, and the number of people supplied. An average rainfall for the West Bank highlands is around 600mm per year. A typical roof catchment of 10m x 10m, supplying a household of 5 people, would provide about 30 litres/capita/day. This would require a 60 cubic metre cistern.

In practice, however, storage capacity is often a limiting factor. Many West Bank villages which rely on rainfed cisterns experience summer water shortages and have to fill their cisterns using tankers which transport water from sources outside the village.

2.3 Springs

The majority of villages in the West Bank are constructed close to artesian springs, which provided the original drinking-water source for the population before cisterns or piped supplies were constructed. In villages without a piped supply, those households which do not have a rainfed cistern will normally collect from the village spring.

Most drinking-water springs are protected by the construction of a concrete storage tank with an overflow pipe or tap from which water is collected. The collecting tank is often at some distance from the spring source, and connected to the source by a pipe.

The distance between the village and the spring varies considerably. In some villages the spring is at the centre of the residential area. In others, the village is constructed at the brow of the hill, with the spring in the valley below. Water is normally carried from the spring to the house in jerry cans or small barrels. Containers may be loaded onto donkeys for transportation.

2.4 Canals

In a few villages in the Jordan Valley, open irrigation canals are used as drinking-water sources. The Beduin settlements in the area also collect from these canals.

2.5 Household Water Storage

Water is stored in a variety of ways in West Bank households. The main kinds of containers used include the following:

1. Metal Storage Tanks
These tanks are locally constructed from sheet metal. They are normally cylindrical, between 50cm and 120cm diameter and 100cm to 150cm in height. Tanks may be on the roof or in the backyard.

2. Cement Storage Tanks
This kind of storage is less common than the metal tanks. Most were constructed before the sheet metal tanks became available.

3. Ceramic Jars (7)
The zir is a traditional method of water storage. Evaporation of water through the porous sides of the container leads to cooling of the stored water. Normal zyar vary between 60cm and 120cm height, neck diameter 15cm to 40cm.

4. Jerry Cans
Jerry cans, made from metal or plastic, are used for water carrying and storing. They are sometimes covered with sacking, which is kept damp in order to facilitate evaporative cooling of the stored water.

5. Bottles
In households with refrigerators, drinking-water is normally cooled in plastic or glass bottles in the refrigerator.

Any or all of these five storage methods may be used in a single household.

3. Water Quality

Most of the gastrointestinal infections which may be transmitted through drinking-water are transmitted via the faecal-oral pathway. For this reason, the extent to which drinking-water is faecally contaminated is an indicator of the health hazard posed by using the water as a drinking source. The group of indicator organisms which are conventionally used to measure the extent of faecal pollution are faecal coliforms, measured as faecal coliforms per 100ml of water (FC/100ml). The World Health Organization (WHO) recommends that drinking-water should be free from faecal coliforms:

> Bacteriologically the objective should be ... to ensure the absence of faecal coliform organisms. If repeatedly found, or if sanitary inspection reveals obvious sources of pollution which cannot be avoided, then an alternative source of drinking-water should be sought wherever possible (8).

It should be emphasised, however, that the presence of faecal coliforms does not prove that drinking-water will invariably cause gastrointestinal infections. The concentration of faecal coliforms at which an infective dose of a particular pathogen is likely to be ingested is poorly understood. In practice, the faecal coliform index allows comparisons of the magnitude of faecal pollution in different supplies, and the measurement of any changes with time.

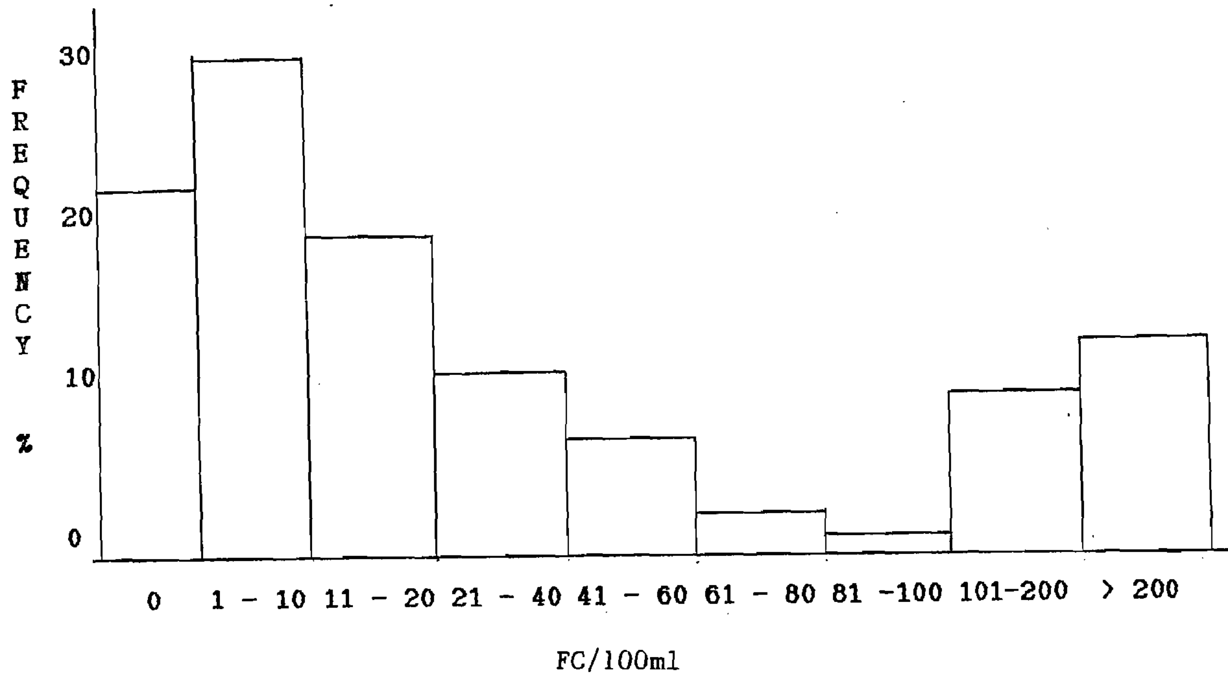
3.1 Piped Water

Ten villages which were supplied with piped, chlorinated water in the Ramallah area were sampled during the spring of 1985. A total of 183 samples were tested, 92% of which showed 0 FC/100ml (9). In view of these results the testing programme was discontinued. In a second survey in the Hebron area 51 samples from piped water systems were tested. 90% contained 0 FC/100ml (10).

3.2 Rainfed Cisterns

In the Hebron area survey, 60 samples were analysed from rainfed cisterns in seven villages. 52% of the samples had less than 10 FC/100ml, and 21% had more than 100 FC/100ml (11).

Figure 3. Frequency Histogram Showing Faecal Coliform Concentrations from 69 Cisterns Sampled in the Hebron Area (12)



Source: Smith, C. (12).

Figure 3 shows a frequency histogram of the data. The main significance of the results was that over half of the cisterns sampled contained low faecal pollution levels (i.e. less than 10 FC/100ml). This confirms that rainfed cisterns can provide high quality drinking-water.

A second, more intensive, survey was conducted in a single village in the Ramallah area, in which 75 rainfed cisterns were sampled (12). The results showed a mean concentration of 5 FC/100ml, with all samples less than 100 FC/100ml. The average FC concentration was higher in cisterns where buckets were used for water removal (7.6 FC/100ml) compared with those cisterns where the electric pump removal method was used (2.6 FC/100ml). This suggested a slight polluting effect from the bucket removal method.

The cisterns of households with animals in their backyards had higher pollution levels than those without animals (29 and 3 FC/100ml respectively). This may have been the result of the pollution of the area above the cistern by the animals. Nevertheless, the results of this study also show that rainfed cisterns can provide high quality drinking-water.

3.3 Springs

Nine springs in the Ramallah area which were being used for drinking were monitored over a period of one year in 1985, during which period five samples were taken from each spring (13). For seven of the springs, one or more of the samples showed pollution levels higher than 100 FC/100ml. Faecal coliform levels tended to be higher in the summer months, the same period when rainfed cisterns tend to dry up and springs are most utilised.

3.4 Canals

In a study of irrigation canal water quality in the Jordan Valley, conducted in 1984, 3 canals which were being used as a drinking-water source were sampled. All showed faecal coliform concentrations higher than 100 FC/100ml (14).

3.5 Water Pollution during Storage

The use of the *zir* for water storage presents a potential risk in so far as stored water may be polluted by contaminated hands and cups during water removal. A study which was conducted in a village in the northern Jordan Valley allowed the precise measurement of the magnitude of pollution during water storage in the *zir*. In each household studied, unchlorinated water was supplied to a courtyard tap, from which the *zir* was filled. Pollution during storage was estimated as the difference between tap water quality and *zir* water quality.

The results showed that, on average, *zir* water faecal coliform levels were 7 FC/100ml higher than those of the tap water. These results suggested that the *zir* storage system need not lead to substantial levels of faecal pollution (15).

4. Sanitation

According to the Israeli Central Bureau of Statistics, in 1981 15% of West Bank households were without a latrine of any kind, while 20% had automatic flushing systems. Thus 85% of households have some kind of excreta disposal system (16). Systems currently used in the West Bank can be divided into 3 main types:

a. Pit latrines.
b. Pour flush latrines connected to soakage pits or piped sewerage.
c. Automatic flushing latrines connected to soakage pits or piped sewerage.

The simple pit latrine is common throughout the West Bank, and was probably the first kind of latrine to be constructed in the villages. The main advantage of the design is that it requires no water to be used. It has the disadvantage that insects tend to breed in the pit, providing a potential vector-borne disease hazard. The latrine also has an unpleasant smell. The practice of covering the squatting hole when not in use is uncommon. Direct drop latrines are normally separate from the house. Figure 4 shows the main features of the pit latrine.

An intermediate system between the pit latrine and the pour flush latrine is found where soakage pits are slightly offset from slabs, connected by a sloping pipe (Figure 5). This system requires some water to flush the excreta down the pipe, though rather less than for a pour flush/water seal system. From a health point of view, the system has similar problems to the pit latrine - insect breeding and an unpleasant smell - although they are less acute than in the direct drop latrine.

The pour flush system contains a water seal "U" bend underneath the defecation hole which separates the pit from the latrine room, thus reducing unpleasant smells or insect hazard. The squatting slab may be made from cement, tiles, or ceramic. The water seal made be made from cement or, increasingly, plastic. Figure 6 shows the details of this system.

There are two main problems with these latrines. Firstly, they must be flushed after use or they will block up, and in villages where water is scarce there may not be enough water available for flushing, resulting in the health hazard of a blocked latrine. A second, associated, problem is that some of the new water seal "U" bends which were designed for automatic flushing latrines are being installed on pour flush systems. These "U" bends require a large volume of water to be flushed and are not suitable for hand flushing. Incomplete flushing may lead to a residual foul smell and risk of blockage.

Soakage pits in the West Bank consist of some kind of pit into which excreta are channelled. The pit may be built so that the permeability of the pit's wall is retained, or it may be sealed. Permeable pits may be lined with open joint blocks, dry stone, or left unlined. Sealed pits may be lined with plastered blocks, have a coat of cement plastered directly onto the soil or rock sides, or simply be constructed in impermeable rock.

Sealed pits are usually constructed where seepage from the pit might present a pollution hazard to nearby land, or a nearby cistern. Pits which are initially intended to be permeable frequently turn into sealed pits as the pores around the pit block up with time. In either case, impermeable pits tend to fill up with sewage regularly, especially when collecting household washwater, and require emptying by vacuum tankers. This incurs substantial running costs for the system.

Compartmentalised septic tanks feeding into soakage pits or drainage fields are not normally constructed in the West Bank.

Figure 4. <u>The Pit Latrine</u>

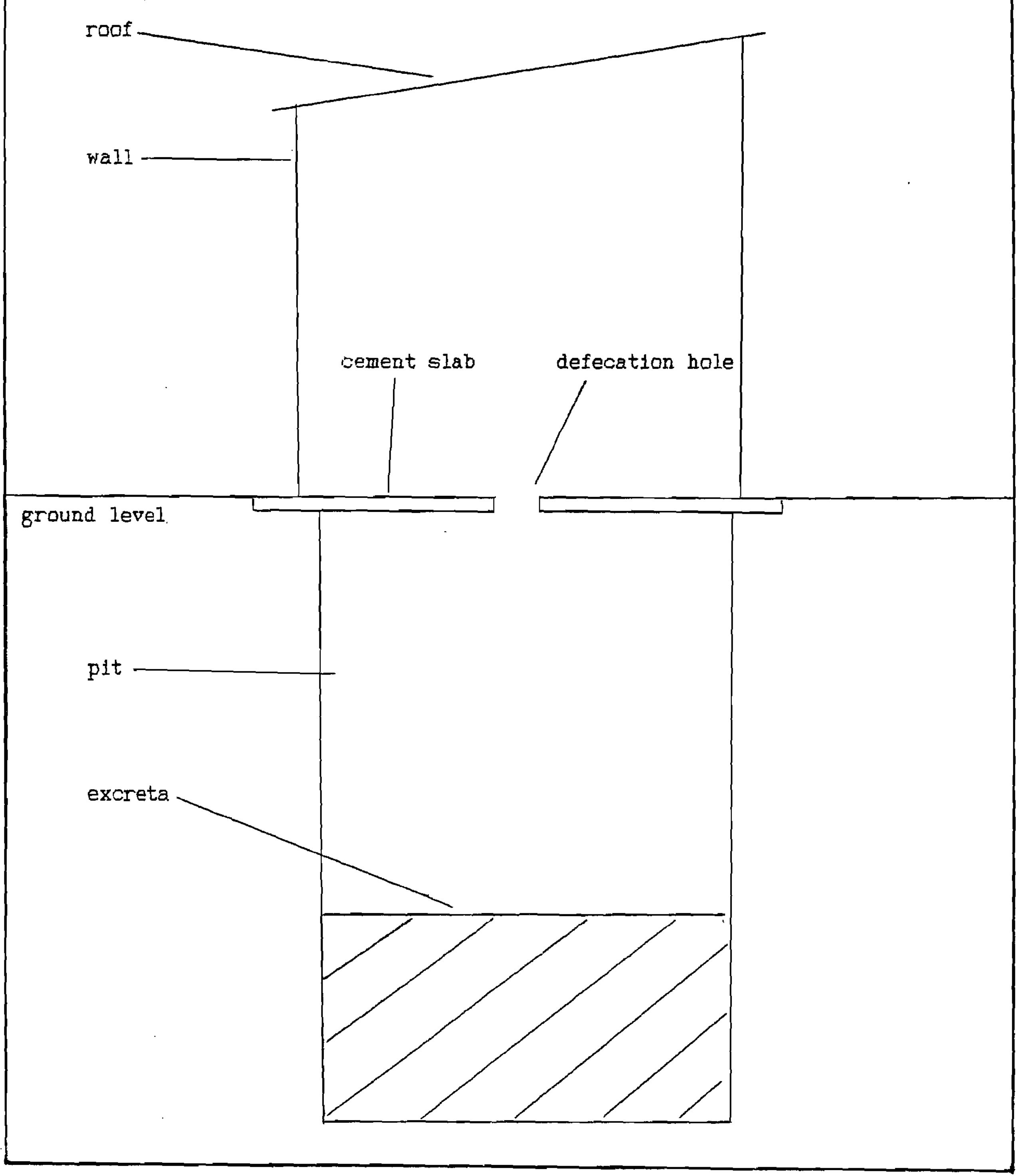


Figure 5. <u>The Offset Pipe System</u>

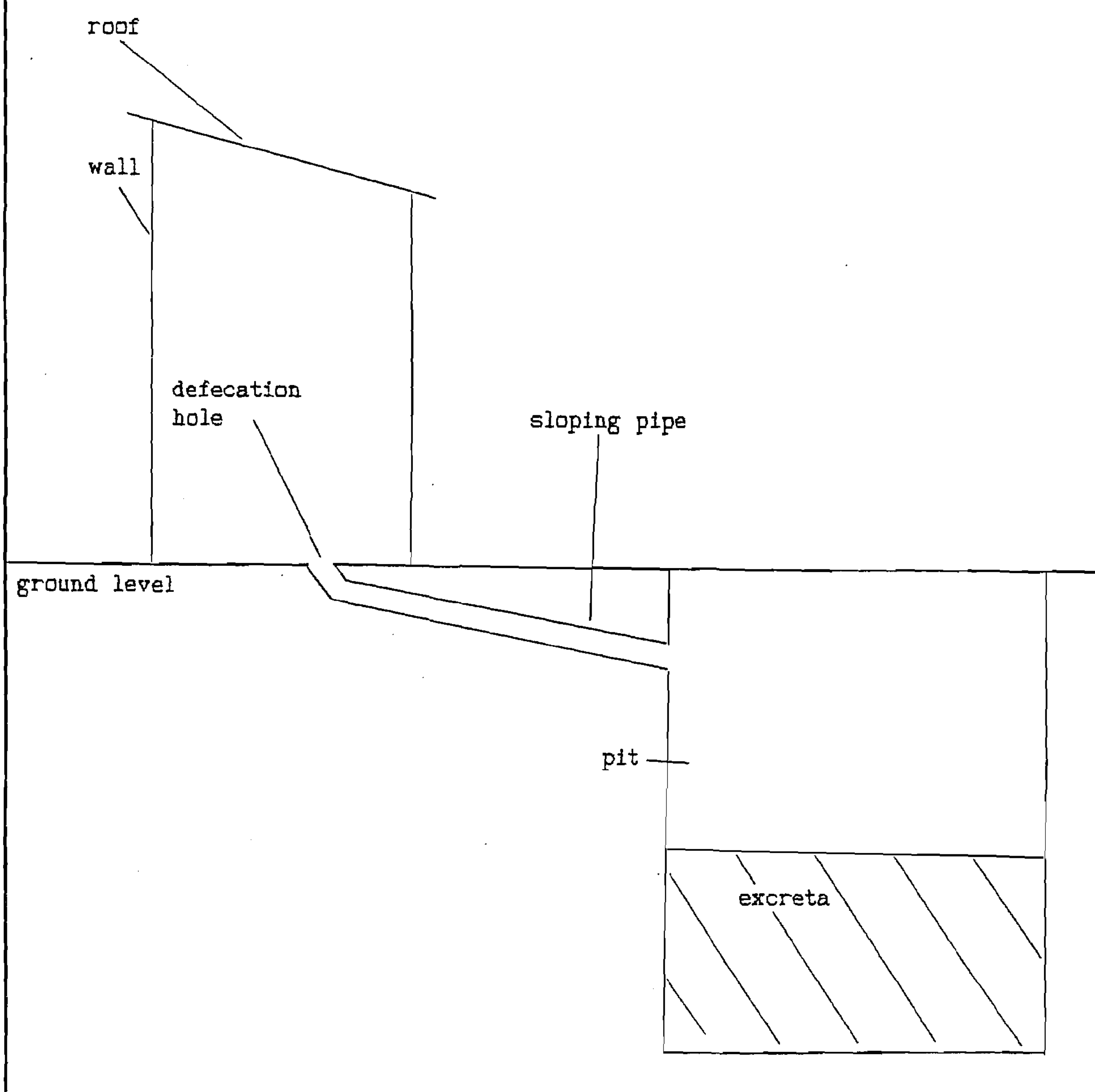
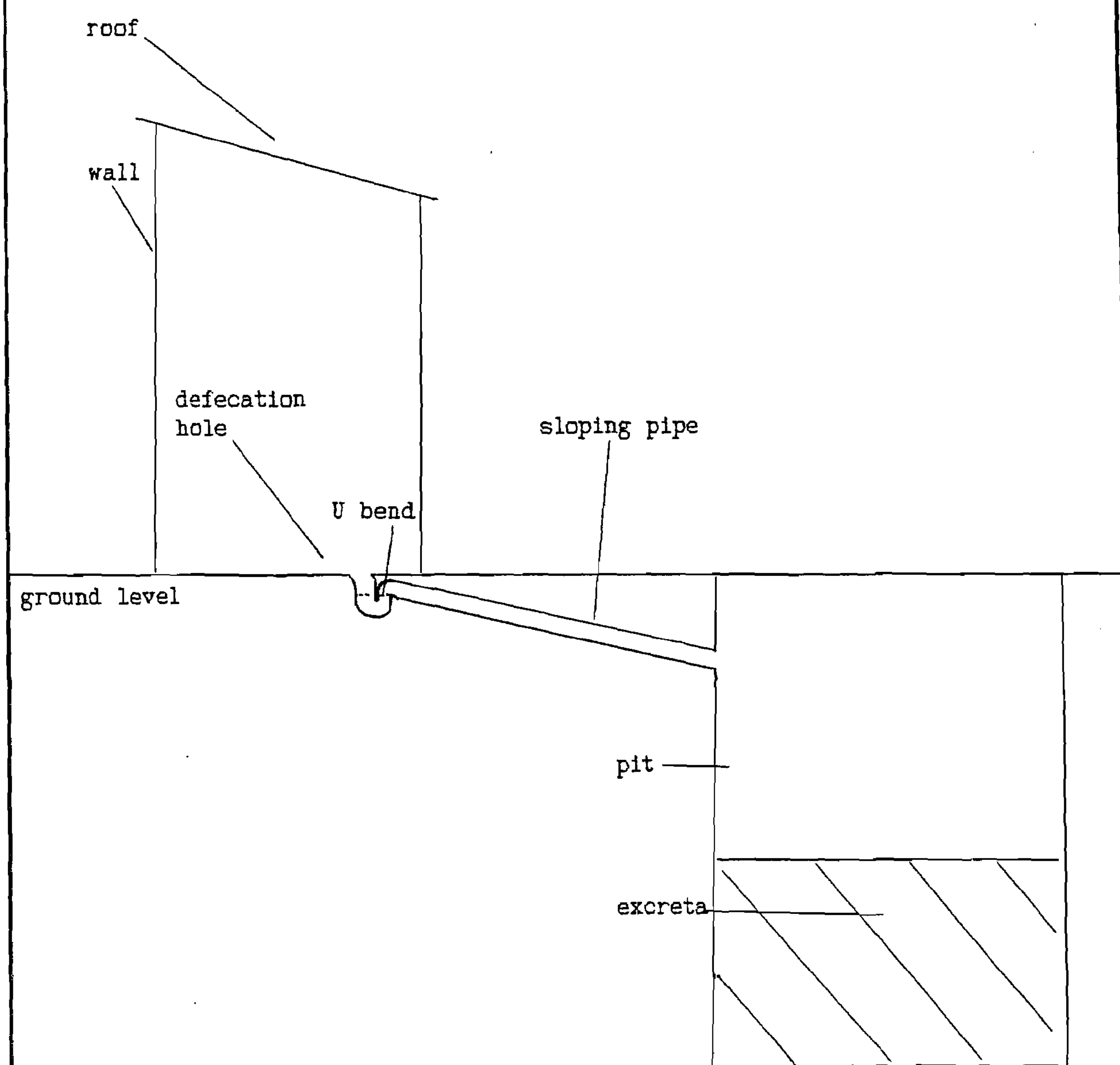


Figure 6. The Pour Flush System



5. Water, Sanitation and Health

The impact of water and sanitation facilities on the health of a population is a complex and controversial subject. The measurement of precise impacts is fraught with methodological difficulties, which has prevented clear conclusions from being drawn (17).

The main disease category associated with water and sanitation facilities is gastrointestinal infections, although other disease categories are also related to a lack of these facilities (for example skin diseases). Most gastrointestinal diseases are spread through the faecal-oral pathway. A public health strategy which aims to reduce the prevalence of these diseases will normally include the provision of a safe water supply and adequate sanitation. It is to be assumed that these facilities will reduce the pollution of the environment by faecal pathogens; reduce the risk of ingesting faecal pathogens in drinking-water; and provide water which can be used to improve the standard of personal and domestic hygiene.

In the West Bank it is unusual for a household not to have a latrine and a drinking-water source. Existing data on water quality suggests that piped water supplies are providing high quality water, and that most rainfed cisterns provide good quality water (Section 3). It cannot be concluded that infective doses of intestinal pathogens are being ingested from drinking cistern water in the West Bank. It must be emphasised, however, that existing data is incomplete and perhaps unrepresentative of the West Bank as a whole.

While it is probable that households using rainfed cisterns will consume less water per capita than those with a piped supply - particularly, if the bucket removal method is used - it is not possible to predict the extent to which changing from a cistern to a piped supply might contribute to a reduction in the risk of gastrointestinal infection.

Precise measurement would require a specialised study, as a number of factors not related to water supply or sanitation also affect the risk of gastrointestinal infection (for example, nutritional status). Methodological care is required to separate the effects of these other variables from that of the water supply or sanitation facilities.

Nevertheless, it is to be expected that the increase in per capita water consumption associated with the acquisition of a piped supply will, to some extent, reduce the risk of gastrointestinal infection. This would be related primarily to the increased hygienic standard facilitated by increased water quantity, rather than to the effect of water quality changes.

A variety of factors related to water supply and sanitation facilities may influence the prevalence of gastrointestinal infections. These include the following:

a. The extent to which the sanitation facilities are utilised by the population, and particularly by young children.
b. The extent to which the excreta disposal systems lead to recontamination of the environment.
c. The extent to which a water supply is utilised for personal and food hygiene.
d. The extent to which a water supply is used to clean the household living area.

These factors illustrate the relevance of combining water and sanitation promotion with more general campaigns related to environmental health.

The prevalence of intestinal parasite infections in a population can provide a useful index of the extent of faecal-oral infections, and also an indication of the dominant types of transmission pathways. Table 4 summarises the results of recent intestinal parasite studies in the West Bank.

The data shows, for the populations studied, the predominance of intestinal protozoan infections over soil-transmitted helminth infections. This might tentatively be related to a classification system proposed by Feachem et al. which distinguished latency as an important characteristic of parasite epidemiology (18). Pathogens which require an incubation period outside the host before becoming infective differ epidemiologically from those which are immediately infective. The former require suitable environmental conditions for embryonation whereas the latter can be passed from person to person directly. The majority of pathogens listed in Table 4 belong to the latter category. Thus existing data suggest that, for much of the West Bank, epidemiological conditions are not suitable for the transmission of the former category (soil-transmitted helminths). This may be related to the sanitary facilities in these areas. The common presence of non-latent intestinal parasites suggests a problem of personal hygiene which may be related, in part, to water supply.

More research is required, however, to establish the factors determining intestinal parasite prevalence in the area, and the relationship with water supply and sanitation.

Table 4. Recent Studies of Intestinal Parasitism in the West Bank

Study	Site	Age Range (years)	Sample Size	Prevalence					
				Entamoeba coli	Giardia lamblia	Entamoeba histolytica	Hymenolepis nana	Ascaris lumbricoides	Trichuris trichiura
Giacaman (1985)	Ramallah	0 - 3	195	3	26	3	3	1	0
Kaspari & Condie (1986)	Four Refugee Camp Schools	6 - 12	455	21	16	4	11	2	6
Condie & Kaspari (1986)	Bir Zeit School	6 - 12	195	8	14	1	0	1	0

Sources: Giacaman; Kaspari & Condie; Condie & Kaspari (19).

6. Implications for Health Development

As piped water reaches more of the population of the West Bank, so comes the potential for an improvement in the health of the population through improved personal and domestic hygiene made possible by the increased quantity of water available. The extent to which an accompanying water quality improvement would also have a significant impact on health is less clear.

In some villages rainfed cisterns may well provide an adequate quantity of high quality water. In such a situation the health benefit of a piped supply would be minimal.

The provision of a piped supply may also create a new problem of sewage disposal. Without some kind of septic tank or sewerage system, the rather ad hoc soakage pits currently in use may become a health hazard with time, as the volume of sewage to be absorbed overloads their absorption capacity. Planning and research are required now for this eventuality, in order to develop technically and financially feasible solutions for rural sewage disposal.

Some of the diseases which are associated with severe environmental contamination - for example cholera and typhoid - are rare in the West Bank. Intestinal protozoa, however, are common infections, and gastrointestinal infections are a major source of child morbidity.

Clearly, a public health strategy aimed at reducing gastrointestinal morbidity should include the provision of safe drinking-water and adequate sanitation as part of its strategy. Merely constructing adequate facilities, however, does not guarantee that their potential health benefits will be realised. More research is needed to investigate the effectiveness of health promotion activities in order to encourage the optimal use of water and sanitation facilities.

The potential health benefits of water supply and sanitation facilities may also not be realised due to other risk factors. Problems related to poverty, such as malnutrition and overcrowding, are examples of such risk factors. Health programmes which aim to reduce gastrointestinal morbidity should address the various factors involved in producing ill health, taking water and sanitation as part of the strategy.

Notes and References

(1) See, for example, Davis, U., Maks, A., Richardson, J., Israel's Water Policies, Journal of Palestine Studies, 34, Vol. IX, No. 2 (Winter 1980), 3-31.

(2) The Statistical Abstract of Israel 1983, Jerusalem: Central Bureau of Statistics, 1984, p. 772.

(3) Ibid., p. 772.

(4) Pontifical Mission for Palestine, Village Survey, Unpublished Data, Jerusalem, 1983.

(5) Twort, A.C., Hoather, R.C., Law, F.M., Water Supply, London: Arnold, 1974, p. 5.

(6) Adler, Yacob et al., The Report of the Joint Committee on Health Services in Judea and Samaria, Unpublished Report of the Joint PLanning Committee on Health Services in Judea and Samaria, Jerusalem, 1984, p. 80.

(7) The Arabic word for this kind of ceramic jar is zir, plural: zyar.

(8) World Health Organization, Guidelines for Drinking-Water Quality, Vol. 1: Recommendations, Geneva: World Health Organization, 1984, p. 22.

(9) Smith, C., Unpublished Data, Community Health Unit, Birzeit University, Bir Zeit, 1985.

(10) Smith, C., Bacterial Quality of Drinking-Water in Seven Villages in the Hebron Region, Community Health Unit, Birzeit University, Bir Zeit, January 1985.

(11) Ibid.

(12) Smith, C., Faecal Coliform Concentrations of Cistern and Stored Household Water in the Palestinian Village of Abu Shkheidem, Community Health Unit, Birzeit University, Bir Zeit, August 1985.

(13) Smith, C., Seasonal Variations of Faecal Coliform Concentrations in Nine Springs in the Ramallah Area, Community Health Unit, Birzeit University, Bir Zeit, October 1985.

(14) Smith, C., Bacterial Quality of Drinking-Water in Eight Villages in the Jordan Valley, Community Health Unit, Birzeit University, Bir Zeit, December 1984.

(15) Smith, C., The Introduction of a New Household Water Storage System into a Palestinian Village and Its Effects on the Faecal Pollution of Stored Water, Community Health Unit, Birzeit University, Bir Zeit, November 1985.

(16) The Statistical Abstract of Israel 1983, op. cit., p. 772.

(17) Blum, D. & Feachem, R., Measuring the Impact of Water Supply and Sanitation Investments on Diarrhoeal Diseases: Problems of Methodology, International Journal of Epidemiology, 12 (1983), 357-365.

(18) Feachem, R. et al., Sanitation and Disease: Health Aspects of Excreta and Wastewater Manegement, World Bank Studies in Water Supply and Sanitation No. 3, London: Wiley, 1983, p. 33.

(19) Giacaman, R., A Profile of Life and Health in Three Palestinian Villages, Community Health Unit, Birzeit University, Bir Zeit, 1985.
Kaspari, S. & Condie, A., Intestinal Parasitic Infection of Refugee Children in Selected West Bank Localities, Community Health Unit, Birzeit University, Bir Zeit, 1986.
Condie, A. & Kaspari, S., An Investigation of Intestinal Parasitic Infection and Haemoglobin Levels in a Bir Zeit School, Community Health Unit, Birzeit University, Bir Zeit, December 1986.

Bibliography

Adler, Yacob, et al. The Report of the Joint Committee on Health Services in Judea and Samaria. Unpublished Report of the Joint Planning Committee on Health Services in Judea and Samaria. Jerusalem, 1984.

Blum, D. & Feachem, R. Measuring the Impact of Water Supply and Sanitation Investments on Diarrhoeal Diseases: Problems of Methodology. International Journal of Epidemiology, 12 (1983), 357-65.

Condie, A. & Kaspari, S. An Investigation of Intestinal Parasitic Infection and Haemoglobin Levels in a Bir Zeit School. Community Health Unit, Birzeit University. Bir Zeit, December 1986.

Davis, U., Maks, A., Richardson, J. Israel's Water Policies. Journal of Palestine Studies, 34, Vol. IX, No. 2 (Winter 1980), 3-31.

Feachem, R. et al. Sanitation and Disease: Health Aspects of Excreta and Wastewater Management. World Bank Studies in Water Supply and Sanitation No. 3. London: Wiley, 1983.

Giacaman, R. A Profile of Life and Health in Three Palestinian Villages. Community Health Unit, Birzeit University. Bir Zeit, 1985.

Kaspari, S. & Condie, A. Intestinal Parasitic Infection of Refugee Children in Selected West Bank Localities. Community Health Unit, Birzeit University. Bir Zeit, December 1986.

Pontifical Mission for Palestine. Village Survey. Unpublished Data. Jerusalem, 1983.

Smith, C. Bacterial Quality of Drinking-Water in Eight Villages in the Jordan Valley. Community Health Unit, Birzeit University. Bir Zeit, December 1984.

Smith, C. Bacterial Quality of Drinking-Water in Seven Villages in the Hebron Region. Community Health Unit, Birzeit University. Bir Zeit, January 1985.

Smith, C. Faecal Coliform Concentrations of Cistern and Stored Household Water in the Palestinian Village of Abu Shkheidem. Community Health Unit, Birzeit University. Bir Zeit, August 1985.

Smith, C. Seasonal Variations of Faecal Coliform Concentrations in Nine Springs in the Ramallah Area. Community Health Unit, Birzeit University. Bir Zeit, October 1985.

Smith, C. The Introduction of a New Household Water Storage System into a Palestinian Village and Its Effect on the Faecal Pollution of Stored Water. Community Health Unit, Birzeit University. Bir Zeit, November 1985.

The Statistical Abstract of Israel 1983. Jerusalem: Central Bureau of Statistics, 1984.

Twort, A., Hoather, R.C., Law, F.M. Water Supply. London: Arnold, 1974.

World Health Organization. Guidelines for Drinking-Water Quality. Vol. 1: Recommendations. Geneva: World Health Organization, 1984.