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Faecal Coliform Concentrations of Cistern and Stored Household Water in the Palestinian Village of Abu Shkheidem

Occasional Papers

Faecal Coliform Concentrations of Cistern and Stored Household Water in the Palestinian Village of Abu Shkheidem

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Summary

The faecal pollution of drinking-water in the Palestinian village of Abu Shkheidem was studied by measuring faecal coliform concentrations in the cisterns and in the stored household water. The average quality of 75 cisterns was 5.01 FC/100ml.

The average faecal coliform concentration of cisterns used with pumps was lower than for cisterns where buckets were used for removal of water (7.61 and 2.61 FC/100ml respectively). The difference in faecal coliform concentrations between stored household water and cistern water was greater in households using bucket removal (28.25 FC/100ml) compared to pump removal (minus 1.42 FC/100ml).

Differences were significant at the 10%, but not the 5% level.

Washing of the cistern the previous summer and distance of latrine from cistern had no measured influence on faecal coliform concentrations.

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1. Introduction

The West Bank lies between the Hashamite Kingdom of Jordan and the 1967 borders of the State of Israel, with a population of approximately 850,000. According to Israeli sources, 50% of the rural population do not have access to a piped water supply (1). These households drink from two sources, rainfed rooftop catchment cisterns and springs. The following study investigates bacterial water quality in one such village, Abu Shkheidem, which lies 10km north of the town of Ramallah.

The village is without a piped water supply, the majority of households drinking from rainfed underground cement cisterns supplied by rooftop catchments. The average rainfall in the area is 600mm/year which occurs predominantly between the months of October and April. In years when the cistern supply is exhausted during the dry season, villagers refill their cisterns from tanker trucks or collect from a nearby spring. The rooftops are made from cement. During the first rain of the season the first flush from the roof is not collected in the cistern.

Water is removed from the cistern in two ways. Some of the households use electric pumps to transfer water from the cistern to a rooftop metal storage tank, which is connected to a tap in the courtyard or the house. Other households remove water from their cisterns by lowering a bucket through a trap door in the roof of the cistern. Water is transferred from the bucket to one of the following three storage vessels:

1. A large ceramic jar (<u>zir</u>) (2). The water is removed from the jar by dipping a cup into the water.

2. A jerry can (<u>galon</u>) (3). Water is poured from the <u>galon</u> into the drinking cup.

3. Bottles.

The purpose of the study was to measure the bacterial quality of water in the cisterns and the household storage vessels in order to evaluate whether the different collection and storage practices had any influence on the quality of water consumed.

The bacterial water quality was evaluated by measuring the concentration of faecal coliform bacteria. This method provides an indication of the extent to which water has been contaminated by faeces of human and animal origin, and it can be used to indicate the risk of pathogenic bacteria being present in the water.

The study was designed to test the following hypotheses:

Hypothesis 1
Cisterns where water is removed by a bucket will tend to have higher concentrations of faecal coliforms than those where a pump is used. The higher level of pollution would be caused by the use of a bucket which is itself polluted.

Hypothesis 2
Stored water which has been collected in a bucket will tend to have higher faecal coliform concentrations than stored water which has been pumped. This would result from a polluted bucket being used to transfer the water from cistern to storage vessel.

Hypothesis 3
Water stored in zyar will tend to have higher faecal coliform concentrations than water stored in galonat or bottles. The contamination would result from the use of a polluted cup for water removal.

2. Methods

Every house in the village was sampled between 29 April 1985 and 4 June 1985. The householder was asked the following questions:

1) Was the cistern cleaned this year?
2) How is water removed from the cistern?
3) Does the cistern have a trap door?
4) How far is the nearest latrine from the cistern?
5) Are animals kept in the household or its garden?

Water samples were taken in the following ways:

1. Cisterns: A flamed stainless steel cup on a wire was lowered into the cistern. (The lower 10cm of the wire was also flamed.) Water was then decanted from the cup into sterilised sample bottles.

2. Zyar: A flamed stainless steel scoop was lowered into the zir.

(In both cases flaming was carried out with a portable gas blow torch.)

3. Taps: The nozzle was wiped with ethanol and ignited, then the tap was left running for one minute before the sample bottles were filled.

4. Jerry cans and bottles: Water was poured directly into the sample bottles.

All samples were taken in duplicates and filled into bottles which had been autoclaved at 121°C for one hour. Samples were then transported to the laboratory and filtered within four hours of collection.

The faecal coliform enumeration procedure followed standard methods recommended by the American Public Health Association (APHA): membrane filtration through 0.45/µm filters followed by incubation on endobroth at 44.5°C ± 0.2°C for 24 hours (4). 100ml of each duplicate were filtered.

After incubation, the number of colonies on each dish was counted. Any colonies not showing the standard E.Coli characteristics (dark red with a metallic sheen) were re-cultured using La Roche "Enterotubes" and the IMVIC tests (5) in order to establish whether they belonged to the faecal coliform group.

3. Results

3.1 Cistern Water Quality (see Table 1)

The mean quality of the 75 cisterns sampled was a faecal coliform (FC) concentration of 5.01 FC/100ml. The influence of four variables - method of water removal, cleaning of cistern the previous summer, distance of latrine from cistern, and presence of animals in the household - was tested using the difference between means test.

The mean quality of cisterns utilising buckets was 7.26 FC/100ml, compared with 2.61 FC/100ml for cisterns utilising pumps. The difference was significant at the 10%, but not the 5% level.

The five households which had animals in the garden had a mean cistern quality of 41.68 FC/100ml, compared with 7.84 FC/100ml for households without animals. The difference was significant at the 10%, but not the 5% level.

The cisterns which had not been cleaned during the previous summer showed no significant difference from those which had been cleaned.

Cisterns with latrines more the 10m away had higher average pollution levels than cisterns with latrines closer than 10m. (Note that this is the opposite of the expected result.)

All cisterns had trap doors.

Table 1. <u>The Quality of Stored Cistern Water</u>

Cistern Category	Number of Samples	Mean Quality (FC/100ml)	Standard Deviation (s)	t	Signi-ficance
Water removed by bucket	40	7.26	2.26	1.39	0.1
Water removed by pump*	33	2.61	2.61		
Cistern cleaned previous summer	66	5.18	17.94	0.09	0.6
Cistern not cleaned previous summer**	6	5.67	7.65		
Cistern less than 10m from latrine	11	1.32	1.98	2.17	0.05
Cistern more than 10m from latrine	64	5.66	3.81		
Animals in household	5	29.20	41.68	1.22	0.1
No animals in household***	63	3.11	7.84		
Total	75	5.01	14.07		

* 2 cases not ascertained
** 3 cases not ascertained
*** 7 cases not ascertained

Table 2. The Difference in Quality between Cistern Water and Stored Household Water

Method of Removal and Storage	No. of Samples	Mean Difference (FC/100ml)	Standard Deviation (s)	t	Signi-ficance
Pump removal; storage in metal tank	26	-1.42	5.91	1.23	0.1
Bucket removal; storage in *zir*, *galon* or bottle	16	28.25	80.67	1.41	0.1
Zir storage	11	12.91	-	-	-
Galon storage	3	1.50	-	-	-
Bottle storage	2	155.50	-	-	-

3.2 Differences between Cistern Water and Stored Water

Differences between *zyar*, jerry cans and bottles could not be tested, as only three jerry cans and two bottles were present in the sample.

Stored water removed from cisterns by a pump had a mean quality of 0.54 FC/100ml (n=26, s=1.3) compared with 29.65 FC/100ml (n=16, s=79.2) for stored water removed by buckets. This difference was significant at the 10%, but not the 5% level.

Stored water removed by bucket was significantly different from the quality of the cistern source water at the 10%, but not the 5% level (see Table 2). Stored water removed by pumps was also significantly different from the cistern source water at the 10% level.

In 32 houses no stored water was available at the time of collection.

4. Discussion

It was not possible to generalise from the data so as to state whether or not the measured water quality provided a "hazard to health". A discussion of the risk of disease transmission through faecally polluted water requires estimates of infective doses, and of probable ratios between faecal coliform and pathogenic bacteria. This information is not yet sufficiently precise to predict whether a particular faecal coliform concentration could correspond to a particular pathogen concentration (6). Rather, the faecal coliform index allows comparisons of relative purity.

The results failed to validate any of the study hypotheses at the 5% level of significance. However, the distribution of data (Figures 1 and 2) does not conform to a normal distribution so that, strictly speaking, the "t" test is not applicable.

The frequency distributions of the results are characterised by the majority of results clustered below the population mean and a few substantially above the mean. These few, relatively large pollution events are of epidemiological interest as potential routes of disease transmission.

Inspection of the data prompts the following inferences:

1. The cisterns used with pumps tended to be cleaner than those where buckets were used, with only 8% of pump removal cisterns having more than 5 FC/100ml, compared with 22% for bucket removal cisterns. 55% of pump removal cisterns had 0 FC/100ml, compared with 35% for bucket removal cisterns. Thus the study succeeded in validating hypothesis 1, which claims that bucket removal will tend to lead to higher FC concentrations than pump removal. Perhaps a more important (and less self-evident) conclusion is that, if used in a hygienic manner, the bucket removal system can be used without polluting the cistern.

2. Similar results were obtained for stored water: while water removed by buckets and stored in _zyar_ tended to be more polluted than water stored in tanks with taps, 18% of _zir_ water contained 0 FC/100ml. This, again, suggests that the cistern-bucket-_zir_ system can provide pollution-free water if used hygienically. However, the cistern-pump-tank system considerably reduces the chances of pollution.

The methodology adopted measured the difference between the quality of cistern water and stored water. Stored water may be polluted either during the process of water removal (for example by a polluted bucket) or during storage. The measurements taken did not distinguish between these two pollution routes. Neither was it possible to distinguish between the effect of different storage containers, as only two galonat and one bottle were sampled.

In 40% of the households using pumps, the stored tank water had fewer FC/100ml than the cistern source. Although this difference was not large, it indicates the possibility of a reduction in the number of FC/100ml during storage. The die-off rate of bacteria is known to be dependent on temperature. Stored tank water will be at a higher temperature than cistern water, and thus bacterial populations in tank water will tend to decrease in numbers faster than in cistern water.

The inverse relationship between latrine distance and cistern pollution established in this study suggests that faecal coliform levels in the cisterns may not be a result of sewage seepage from latrine pits.

Neither was there any significant difference between the water quality of cisterns which had and those which had not been cleaned the previous summer.

Only five households reported having animals on the premises. These five had a mean cistern quality of 29 FC/100ml, compared with 3 FC/100ml for the other cisterns, which strongly implicates the role of animals in contributing to poor hygiene around the cistern. The difference was significant at the 10% level of significance.

Figure 1. Cistern Water Quality by Method of Removal

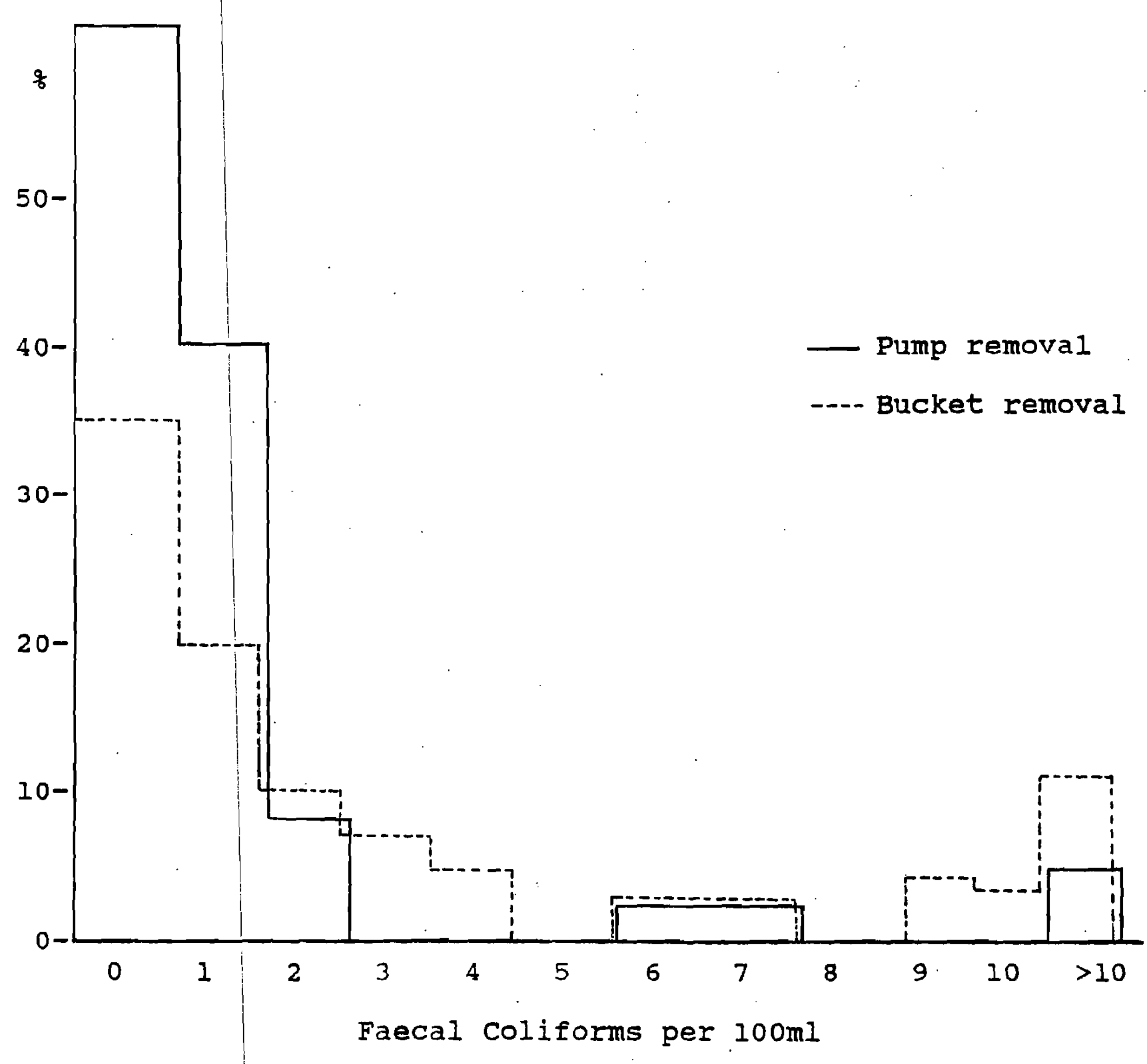
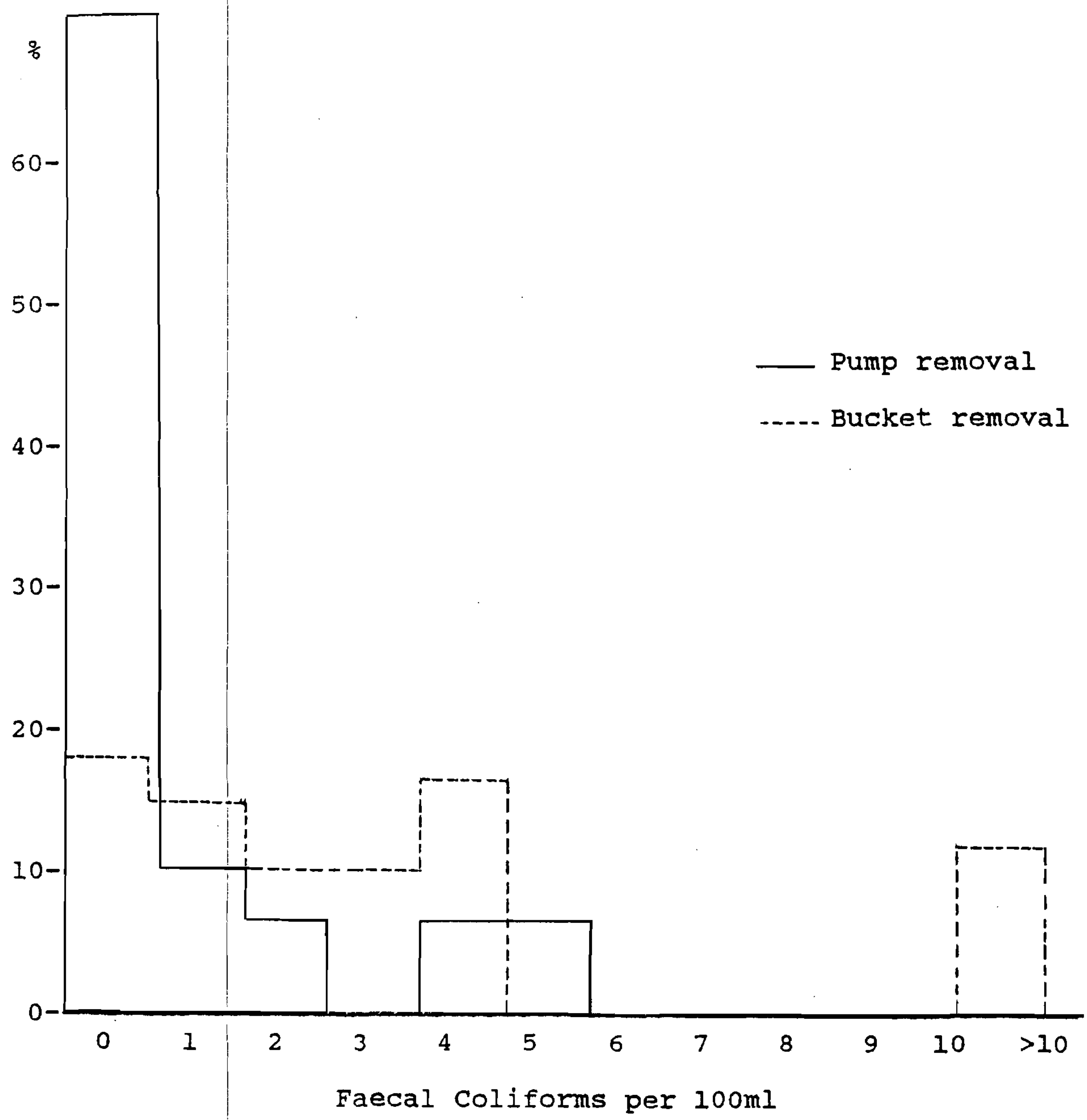


Figure 2. Stored Household Water Quality by Method of Removal



Notes and References

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

(2) Plural form: zyar.

(3) Plural form: galonat.

(4) American Public Health Association, American Water Works Association, Water Pollution Control Federation, Standard Methods for the Examination of Water and Wastewater, 15th, rev. ed., Washington: American Public Health Association, 1981, pp. 814-815.

(5) Ibid., p. 825.

(6) Feachem, R. et al., Water, Health and Development: An Interdisciplinary Evaluation, London: Tri-Med, 1978, p. 169.

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American Public Health Association, American Water Works Association, Water Pollution Control Federation. Standard Methods for the Examination of Water and Wastewater. 15th, rev. ed. Washington: American Public Health Association, 1981.

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