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Field testing water quality in Papua, New Guinea

INTRODUCTION

For rural drinking water supplies in tropical areas one of the most important measures of water quality is the number of faecal coliforms per 100 mL (ref.1). However, the standard tests for faecal coliforms are relatively expensive. They require very close temperature control during incubation, and can only be carried out by someone trained in laboratory techniques.

A simple field-test for detecting faecal pollution in drinking water has been proposed (ref.2). The test uses a cheap, easily prepared, dried media contained in a 20 mL sterile sampling bottle. The sample, collected directly in the bottle, requires no preparation before incubation. Incubation can be between 30 and 37 deg.C.

This cheaper and simpler field-test appears to be more suitable than the standard test for measuring water quality in low-cost rural water supply schemes, where access to laboratory facilities is poor. However, little information is available about how it performs.

The paper compares the results from the field-test with results from a standard method for faecal coliforms. The field-test is compared with the results for concentration of faecal coliforms because, in tropical areas, these have been shown to be better indicators of faecal contamination than total coliforms (ref.3).

The limitations of the test are then described. The quality of water from different types of sources tested during this work is presented, and recommendations are given for use of the simple field-test in rural water supply schemes.

METHODS

Simple field-test

The method used is similar to that given in reference 2.

The incubation medium is made by dissolving 20g of peptone, 1.5g of dipotassium hydrogen phosphate, 0.75g of ferric ammonium citrate, 1.0g sodium thiosulphate, and 1 mL of teepol in 50 mL of distilled water. This is sufficient for over 50 tests.

The sample bottles are McCartney bottles which hold at least 20 mL. Sufficient folded absorbent paper is placed in each bottle to absorb 1 mL of media. This volume of media is added to each bottle. The bottles are then capped loosely, sterilised, and finally dried.

The test involves filling the bottle with about 20 mL of sample and replacing the cap. It is then incubated between 30 and 37 deg.C. for 12 to 18 hours. If the contents of the bottle turn black during the incubation period then the test is positive and the water is considered contaminated.

Faecal coliform test

A membrane filtration test was used to determine unconfirmed faecal coliforms (ref.4). The filter papers and media were supplied by Millipore Corporation and Difco, respectively.

Sampling area

A hand-pump testing project sponsored by the World Bank, and carried out by the PNG Department of Works, Department of Health and the Appropriate Technology Development Institute, is taking place in the Markham Valley near Lae (ref.5). This project included a water quality monitoring programme, and most of the results in this paper come from that area. Additional results come from settlements in Lae, and from rural supplies in the Western Province. All samples were collected during 1985.

EVALUATION OF THE FIELD-TEST

Method

Samples collected for faecal coliform determinations were also analysed using the field-test. In this way 122 samples were analysed by both methods. The samples were transported to the laboratory in insulated containers, and both the faecal coliform test and the field-test were carried out on the day of sampling.

In addition to this comparison with a standard test, the conditions used for the incubation were examined. This is important if the test is to be used in the field. In PNG overnight air temperatures can fall below 20 deg.C, and stringent incubation periods are often inconvenient.

Twenty two samples were used in this part of the investigation. Each sample was used to fill six replicate field-test bottles. Each replicate was then incubated at a different temperature (6,15,20,24,30 & 37 deg.C). The bottles were inspected at three times, after 16, 19 and 24 hours of incubation. The positive results obtained under the standard incubation conditions (as used above) are assumed to be correct. Different results are therefore taken to be either false positives or false negatives.

Results

Comparison of the field-test with the standard test for faecal coliforms gave the results shown in Figures 1 and 2. The field-test tubes which gave a negative result (no discolouration) were closely correlated with with low faecal coliform numbers. Almost half of the samples contained no faecal coliforms (FC), and 94% contained 10 or less FC per 100mL. Only three of the samples contained more than 10 FC per 100mL, and the highest concentration found was 72 FC/100mL.

The field-test tubes which gave positive results (discoloured), tended to be more highly contaminated. However, a significant number of the samples which gave a positive result contained only low numbers of faecal coliforms. Twenty per-cent of the samples contained less than 1 FC/100mL, and 37% contained less than 11 FC/100mL.

The temperature of incubation has a strong influence on the number of positive results which were obtained. At low temperatures (less than 20 deg.C.) bacterial growth was inhibited and no positive tubes were observed. At temperatures above 20 deg.C the number of positive tubes increased with temperature. The highest number of positive samples were found at 30 and 37 deg.C. This indicates that at lower temperatures there will be more false negative results.

The incubation period also influences the number of positive results. At 37 deg.C. the same number of positive tubes were observed after 19 hours incubation as after 16 hours incubation. After a further five hours of incubation an additional seven tubes became discoloured. Long periods of incubation are therefore likely to increase the number of false positive results.

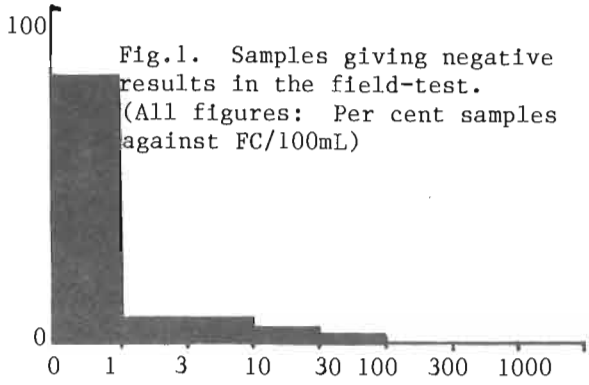

Fig.1. Samples giving negative results in the field-test. (All figures: Per cent samples against FC/100mL)

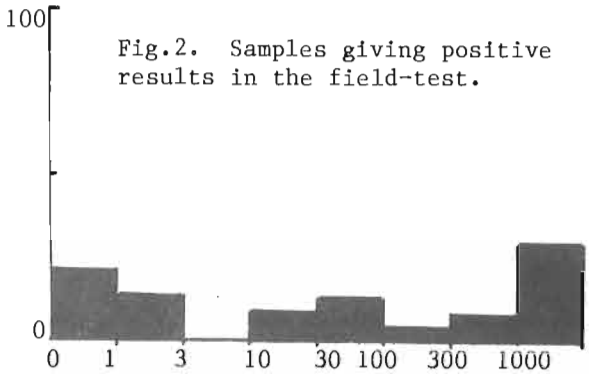

Fig.2. Samples giving positive results in the field-test.

Discussion

The results of the comparison between the field-test and the standard test for unconfirmed faecal coliforms show that samples which give a negative result with the field-test are likely to contain less than 10 FC/100mL. This is in agreement with the results found by Manja etal (ref.2). They found that in 554 samples which gave negative results with the field-test, 99% contained 10 or less FC/100mL.

They also found that the main discrepancies between the tests were in samples with low concentrations of faecal coliforms. They attributed some of these discrepancies to the normal variability of the standard test method at such concentrations.

World Health Organization Guidelines and Papua New Guinea national standards (references 1 and 6) recommend that water supplies should contain no faecal coliforms per 100mL. However, in many rural areas this is impossible to achieve within present economic constraints. Less stringent local water quality objectives must therefore be adopted. Some authors have suggested that 10 FC/100mL is a satisfactory objective (refs.2,7).

The field-test can be used to screen water

sources to identify those which meet such a criteria. However, since the test may give a significant number of false positive results, a preferred water source which does not pass the field-test may then need to be analysed for faecal coliform.

To avoid false negative results the field-test tubes must be incubated between 30 and 37 degrees centigrade. Such a range of temperature can be maintained in the field by a battery operated air incubator, by an insulated container containing warmed water, or by keeping the tubes close to one's body.

Over-long incubation will produce more false positive results. However, incubation periods between 12 and 20 hours seem acceptable.

QUALITY OF RURAL WATER SOURCES

The main purpose of the sampling programme in the Markham Valley was to determine whether the water quality provided by the shallow-well handpumps was significantly better than that for the traditional water sources. The pumps are similar to the Blair design and are sited directly above the wells. This could have resulted in contamination of the well if the seal around the pump-head was inadequate.

Results

Over 250 samples from different water sources were analysed during the study. The results have been classified according to the type of source, and are presented in Figures 3 to 9.

The shallow-wells with handpumps (Fig.3) were found to give the best quality water, 92% of the wells had less than 11 FC/100mL.

The other non-traditional improved type of supply, rainwater collection from galvanised roofing (Fig.4), also provided fairly good quality water. Of all rainwater supplies 68% had less than 11 FC/100mL. The quality of water depended to some extent on the type of storage provided. Storage tanks which were were enclosed or had lids (Fig.5) provided better quality water; 83% of these contained less than 11 FC/100mL. Only 43% of uncovered tanks (Fig.6) had such low concentrations.

In contrast, the traditional sources tended to be more contaminated. Only 58% of seepage pits and springs (Fig.7), 14% of drum wells (extremely shallow open wells) (Fig.8), and 4% of streams and rivers (Fig.9) met the criteria of a maximum of 10 FC/100mL. Many of these type of sources were extremely contaminated, having over 1000 FC/100mL.

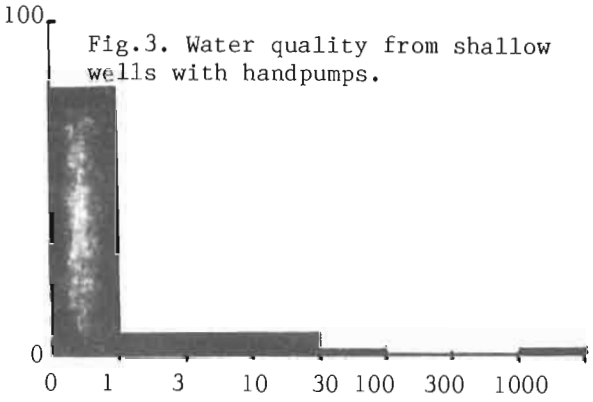

Fig.3. Water quality from shallow wells with handpumps.

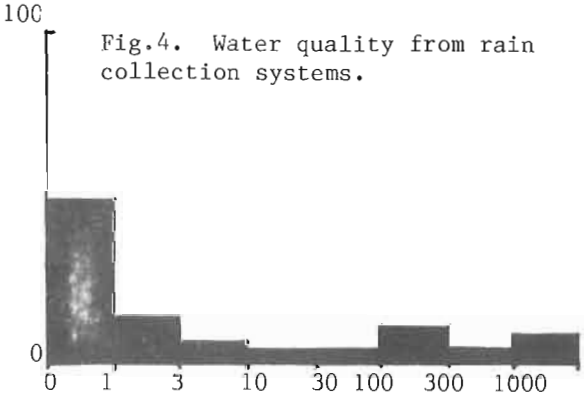

Fig.4. Water quality from rain collection systems.

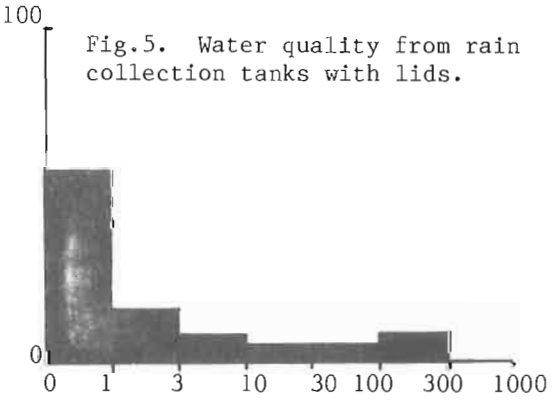

Fig.5. Water quality from rain collection tanks with lids.

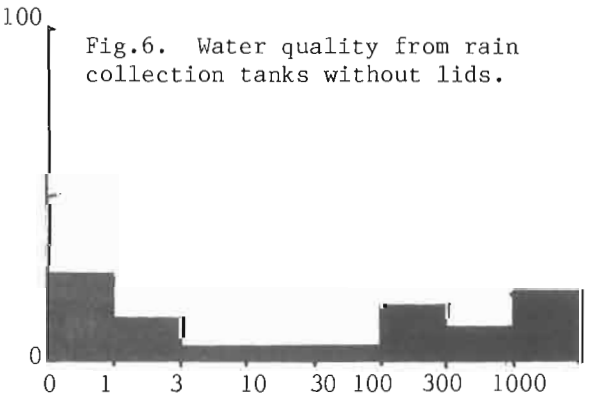

Fig.6. Water quality from rain collection tanks without lids.

Discussion

Previous studies have demonstrated, as does this one, that many rivers and streams in PNG are grossly contaminated, with high faecal coliform concentrations (refs.3,8,9). They

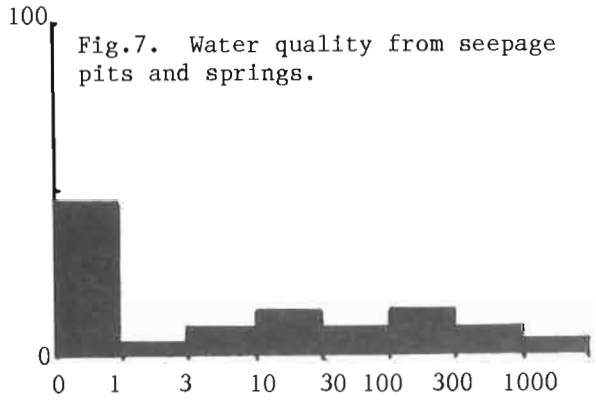

Fig.7. Water quality from seepage pits and springs.

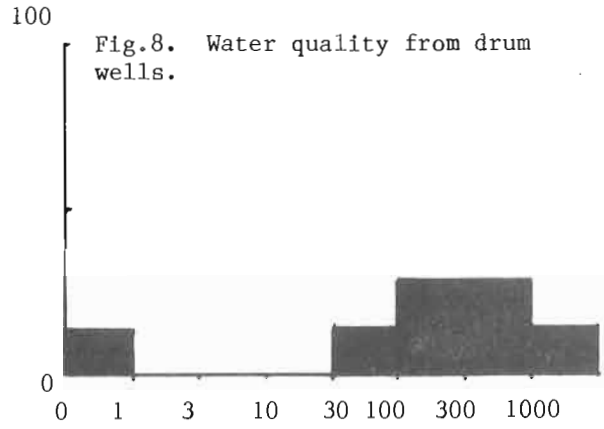

Fig.8. Water quality from drum wells.

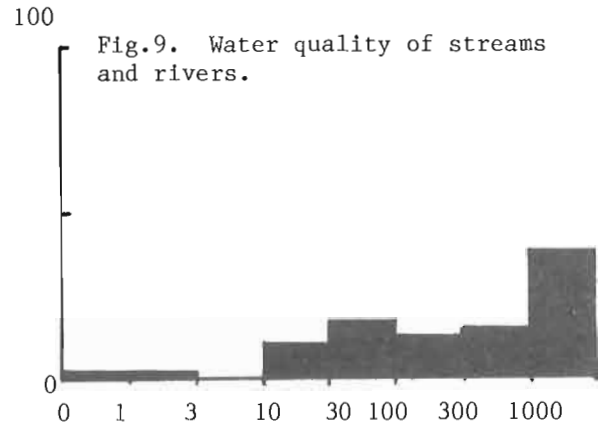

Fig.9. Water quality of streams and rivers.

are often not suitable for community drinking water supplies.

The best quality water is provided by "properly constructed and situated wells" (ref.10). Despite early fears about the quality of the pump-head seal on the PNG Blair pump, this present study shows that the wells are adequately protected against contamination.

The quality of water from such wells has been found to be so good that (if proper care is taken in siting and construction) there is little point in carrying out regular water quality tests.

Properly constructed rainwater collection systems, with enclosed storage tanks, can also provide good quality water. However, the per capita capital cost tends to be much higher than for hand-dug shallow wells.

RECOMMENDATIONS

Use of the field-test is appropriate for low-cost rural water supply programmes, where standard faecal coliform tests are difficult to carry out routinely.

Properly constructed shallow-wells with handpumps give good quality water. Little benefit is gained from testing the quality of water from such wells.

In Papua New Guinea gross faecal contamination of surface water is extremely common. Surface water used as a source for an improved drinking water supply should therefore always be tested. This will permit the elimination of those sources which present the most serious public health risks.

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