Field water quality testing in emergencies

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In many emergency situations it is necessary to undertake rapid assessment of water sources to determine their suitability for the supply of drinking water to affected communities. A key aspect of this assessment is to determine the microbiological quality of the water in order to determine the water treatment requirements. Most conventional methods of microbiological water quality field testing rely on membrane filtration which is relatively difficult to apply in a precarious field situation and requires significant training in the operation of equipment. There are, however, alternative methods available on the market which offer improved ease of use. This factsheet describes some of the key options available, with their advantages and limitations, and outlines a recommended field approach for microbiological water quality testing in emergencies.

Objectives

In an emergency situation a method of microbiological water quality testing is required which:

- is simple to understand and use (requiring minimal training);

- achieves results rapidly (within 24 hours);

- does not require many items of equipment (such as chemicals, power source, incubator etc.);

- is relatively inexpensive; and

- is reasonably accurate (especially at coliform concentrations above 100cfu/100ml)

Many relief agencies use the guideline values given in Table 1 (adapted from Médecins Sans Frontières, 1994) to determine when water treatment is required.

Table 1. Guideline values for water treatment requirements in emergencies	
Faecal (thermotolerant) coliform concentration	**Remark / Action**
<10 cfu / 100ml	Water may be consumed as it is
10 - 100 cfu / 100ml	Treat if possible but may possibly be consumed as it is
100 - 1000 cfu / 100ml	Must be treated
>1000 cfu / 100ml	Rejected or treated very thoroughly

It is therefore most crucial that coliform concentrations above 100cfu/100ml can be detected accurately. However, it should also be possible to detect levels between 10 and 100cfu/100ml.

Methods available

In an emergency there is insufficient time to send samples to a laboratory for analysis. Consequently, field methods are required that can be conducted on site. The key field methods available fall into three categories;

- Membrane filtration;

- Presence/Absence; and

- Petrifilm.

Membrane filtration

Membrane filtration is the traditional method used to detect total and faecal (thermotolerant coliforms). Commercial field testing kits utilising membrance filtration include the DelAgua®, Coliscan® and the Wagtech® portalab. The general process used is as follows:

- A Lauryl Sulphate Broth (or alternative medium) is prepared (this is designed to promote the growth of coliform bacteria and inhibit the growth of other bacteria);

- All equipment is sterilised (using a flame or by boiling);

- The membrane pad is soaked in the prepared broth;

- A 100ml water sample is pumped through the pad;

- The pad is then placed (with the use of sterilised tweezers) in a petri-dish;

- The dish is incubated at 45oC for 18-24 hours;

- The colony forming units are counted on pad.

Membrane filtration field testing kits:

- are relatively difficult to use in the field, especially in an emergency situation;

- require thorough sterilisation of all equipment that comes into contact with the sample;

- require an incubator able to maintain a constant temperature of 45oC for at least 18 hours;

- require a range of chemicals and consumables.

Given the above limitations, results from field tests using membrane filtration are not always reliable, especially when the operator has not been adequately trained, and it is commonplace for kits to be discarded or rarely used.

Presence/absence (P/A)

Presence/Absence tests are designed to detect the presence (or absence) of total and faecal coliforms in a water sample (commonly 10ml). The test does not enumerate the level of coliforms but simply indicates whether or not they are present. There are a number of commercially available P/A products such as Colilert® and Coliquick®. The general process used is as follows:

- A powdered reagent is added to a 10ml sample;

- The sample is incubated at 35oC for 24 hrs;

- The results are read:

    - Colourless = negative

    - Yellow = total coliforms present

    - Yellow/fluorescent = faecal coliforms present (tested with a UV lamp).

In order to enumerate the levels of total or faecal coliforms the **Most Probable Number (MPN)** method can be applied. In this case:

- The water sample is dispensed into 10 tubes (each of 10ml and containing the reagent);

- The samples are Incubated at 35oC for 24 hours;

- The number of positive tubes (out of ten) is recorded;

- Table 2 is used to determine the most probable coliform concentration.

Table 2. MPN Index	
Number of positive tubes	**MPN Index cfu / 100ml**
0	<1.1
1	1.1
2	2.2
3	3.6
4	5.1
5	6.9
6	9.2
7	12.0
8	16.1
9	23.0
10	>23.0

The Presence/absence test:

- is easy to use (no media preparation is needed);

- does not need an incubator (samples can be incubated on the human body);

- can detect presence/absence rapidly;

- when the MPN method is applied can be used to accurately determine coliform counts up to 23 cfu/100ml (dilutions are needed for higher concentrations);

- is highly portable and durable (plastic tubes non-breakable and can be stored for up to 18 months);

- is relatively inexpensive for P/A (approx. 0.5 Euros per single 10ml test) but costs increase ten fold when using the MPN method.

Petrifilm™

Petrifilm™ plates are a commercial product consisting of sample-ready plates with built in grid facilities, which can be used to enumerate total coliforms and *E. Coli* (95% of faecal coliforms are *E. Coli*). The process used is as follows:

- A 1ml sample is dispensed (using a pipette) onto a Petrifilm™ plate;

- A spreader is applied across the overlay film to spread the sample across the plate;

- The Petrifilm™ plate is incubated at 35°C for 24 hours;

- The colony forming units are counted on Petrifilm™ plate (*E. Coli* are surrounded by a blue precipitate to distinguish from total coliforms).

Petrifilm™:

- is easy to use (no media preparation is needed);

- does not require an incubator (the plates can be incubated on the human body);

- can be used to accurately determine coliform counts ABOVE 100cfu/100ml only;

- is highly portable and can be stored for up to 18 months;

- is relatively inexpensive (approx. 0.5 Euros per test).

Key issues for field testing

Given the specific needs of microbiological water quality testing during an emergency there are two major advantages of Presence/Absence and Petifilm™ methods:

1. Ease of use; and
2. Samples can be incubated on the human body.

The major constraints of membrane filtration in an emergency field situation are the need for careful sterilisation and powered incubation. Methods which do not require such complex and sensitive procedures and which can be incubated by simply placing the samples in contact with the human body offer major comparative advantages. Presence/Absence tubes and Petifilm™ plates are most easily incubated on the body by placing them in a small pouch (such as a money belt) in contact with the skin. Petifilm™ plates can also be taped directly on to the body. Given the required incubation temperature of 35°C and the human body temperature of 37°C experiments have shown that the human body is just as effective an incubator as a laboratory incubator for these methods.

It must be stressed that microbiological water quality testing should be accompanied by appropriate sanitary surveys of water sources to identify potential risks to water safety. For more information refer to the WHO Guidelines for drinking-water quality. Vol. 3. Surveillance and control of community supplies (1997).

Recommended field approach

Based on the information provided above, the following field approach to microbiological water quality testing in emergencies is recommended:

- At least three 10ml samples for each water source should be collected and dispensed into a P/A (e.g. Colilert®) tube and incubated on the human body for 24 hours to detect the presence or absence of faecal coliforms (95% E-coli).

- If all three samples are negative the water may be deemed safe to drink as it is.

- If any of the samples prove positive, at least three 1ml samples should be tested using PetrifilmTM incubated on the human body for 24 hours. This will determine if the level of contamination is high (>100cfu/100ml). If so, an appropriate water treatment process should be planned.

- If all the PetrifilmTM results are negative, this means there is low level contamination only. The MPN method can then be used with the P/A test to enumerate the contamination levels if more accuracy is required (at least ten 10ml samples should be incubated on the human body for 24 hours). If the MPN method indicates 23 cfu/100ml or above an appropriate water source protection and/or water treatment process should be planned, otherwise the water may be deemed safe to drink as it is.

This process is summarised in Figure 1.
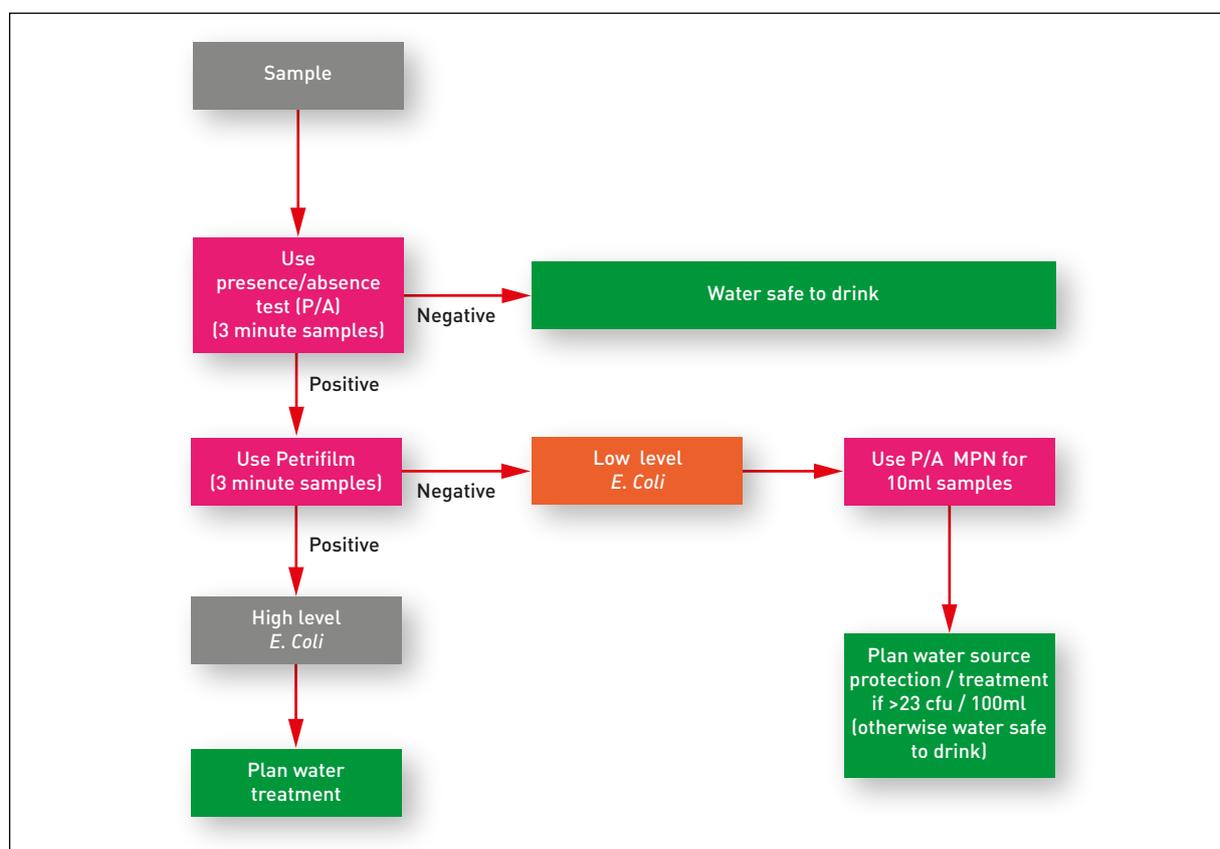
Figure 1. Recommended field approach for water quality testing in emergencies

References

Médecins Sans Frontières (1994) *Public Health Engineering in Emergency Situation*. Médecins Sans Frontières: Paris.

World Health Organization. (1997) *Guidelines for drinking-water quality. Vol. 3. Surveillance and control of community supplies*. World Health Organization: Geneva. (can be accessed via http://www.who.int/water_sanitation_health/dwq/en/)

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