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## Article

Drinking water in the district of Mfou, Cameroon : bacteriological  
assessment and possible interventions at the point of use

HURST, Samia, *et al.*

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## DRINKING WATER IN THE DISTRICT OF MFOU, CAMEROON: BACTERIOLOGICAL ASSESSMENT AND POSSIBLE INTERVENTIONS AT THE POINT OF USE

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Our dependence on water makes it an ideal vehicle for numerous pathogens. The *World Health Report* recorded 1.7m deaths and a burden of disease of 61.1m DALYs due to infectious diarrhoea alone in 2002<sup>1</sup>. Because of this, important efforts have been invested in increasing the availability of clean water sources in the world's poorest areas. It has, however, been shown that water can become contaminated during storage and handling<sup>2-5</sup>. Since water storage requires many steps, all of which are a risk for contamination, this is not surprising. In such cases, providing a community with a clean source of water only incompletely addresses the problem of water-born disease and the impact of water on faecal-oral transmission.

This is the second part of a two-part study on drinking water quality in the district of Mfou, Cameroon. The first part focused on the quality of water at the source (see Motamed et al, page 61). In this study, conducted in the same area, water storage and handling were observed, along with the bacteriological quality of drinking water at the source and the point of use. Based on observations, various means of water treatment at the point of use are discussed and the advantages and drawbacks of their implementation are assessed.

### **Methods**

Cameroon stretches over 475,440 km<sup>2</sup> from the sub-Saharan region to the tropical forest in Central Africa. Its population of 14.3m inhabitants is made up of almost 200 ethnic groups. The district of Mfou is close to the capital, Yaounde, in the South. The Cameroon National Water Society supplies water to the larger towns, but failures are frequent. Villages get their water from traditional wells and pump wells. A well-boring project funded in part by foreign aid is active in the district of Mfou. Underground water is abundant and close to the surface, with some houses equipped with cisterns.

For this study, water carriers were followed both from pump-wells and traditional wells. In each case, observations were made on how water was handled and stored. Samples were taken for bacteriological analysis at the well or water source, and again at each step that involved handling the water or changing its container. Water from the well had already been analyzed as part of the previous study. A new sample was taken on the day where storage and handling was observed to avoid the risk that variable contamination levels in the well might become a confounding factor.

The project was explained to the appropriate local authorities, water carriers, and, where appropriate, other members of the household. Authorization was obtained from each of them.

To avoid contamination by contact, water was sampled from containers by pouring from the container to the sampling jar. Samples from pump-wells were taken by first pumping enough water out to ensure that the sample came from the well, not from the pipe. The rims of the containers and the outlets of the wells were kept over a flame and then allowed to cool before taking the samples.

Samples were tested for human fecal contamination using membrane-filtration cultures of thermo-tolerant coliforms. Portable Millipore® material was used to cultivate the samples and colony forming units (CFUs) were counted visually. Samples were taken during the dry season in March, and during two rainy seasons in April and September.

### **Results**

Results confirmed an alarming frequency of water contamination at the point of use in the district of Mfou. In the observed area, the availability of clean sources of water did not guarantee that clean water was drunk. These results are similar to others described elsewhere<sup>2-5,7</sup>.

Cultures of samples from traditional wells are shown in Table 1. They showed an important degree of contamination both at the source and at the point of use. Water drawn from pump-wells (Table 2) was found to be free of contamination by thermo-tolerant coliforms in three cases (21%). Under the extended threshold for drinking water of 10 CFU/100ml, 57% of the samples were fit for human consumption. Yet, this remains a low figure. The contamination of water also increased with storage and handling in general, and discrepancies between different cases were great enough to make the risks to individuals unpredictable.

Samples of rain water, which were collected as drinking water in two metal pans, were also analyzed. This water was not transferred or otherwise handled before our visit. Despite this, analysis showed innumerable CFUs in both instances. This is a strikingly example of the risk to water quality during handling and storage.

Representative examples of water storage and handling are listed in Box 1 (page 66). Water handling usually involved a first container that was either dipped into the well or filled from a pump. The water was then carried home, and poured into a different container that served as a reserve. Water was drawn from the household re-

Table 1 Traditional wells

CFU/100ml	At the well: N (%)	At the point of use: N (%)
0-10	2 (22)	1 (11)
11-100	3 (33)	1 (11)
>100	4 (44)	7 (77)
<b>Total</b>	9 (100)	9 (100)

Table 2 Pump wells

CFU/100ml	At the well: N (%)	At the point of use: N (%)
0-10	14 (100)	8 (57)
11-100	—	3 (21)
>100	—	3 (21)
<b>Total</b>	14 (100)	14 (100)

serve with metal or plastic cups, which were dipped into the water and then used for drinking.

### Discussion

These results demonstrate situations where the advantage of having a clean water source is lost during storage and handling. In certain cases, contamination was just as important at the point of use as that of water coming from a contaminated source. This is especially concerning in areas where the incidence of infectious diarrhoea is high, and where storage of water is usual. Based on these observations, the most regular risks of contamination were the following:

- use of an uncleaned container, either for transport or as a household reserve
- use of a household reserve already containing contaminated water
- use of an uncovered household reserve
- use of an uncleaned cup when drawing water from the reserve for use
- dipping one's hand into the water when drawing it for use.

This kind of situation is frequent in tropical climates in resource-poor areas. It is the result of poverty and difficult living conditions in a climate that is very favourable to bacterial growth. It could be remedied by placing a clean water faucet and adequate sanitation for the disposal of excreta in every home, however, this is not likely in the near future. Water quality could potentially be improved by simple measures such as systematically washing all containers, covering them, and avoiding hand contact with the water. In addition, several techniques for water treatment at point of use have been assessed for efficacy. Some of these methods are reviewed below, along with their use. Combining several methods may also increase their impact<sup>8</sup>.

### DISINFECTION AT THE POINT OF USE

#### Boiling

This technique is recommended by the Koran, and thus has cultural grounding in certain areas. Approximately 1kg of wood is required to boil 1L of water. It is necessary to maintain the water at boiling temperature for five minutes in order to kill or inactivate the pathogens it could contain. This time must be increased by one minute for each 1000m over 1000m above sea level. Loss through evaporation is always present and increases with boiling time. For this reason, the necessary time needed is almost never reached. Yet, recontamination is possible during storage. Extensive use of wood can have a negative impact on ecological and agricultural conditions in certain areas. Risks also include scalding, especially for small children.

#### Chlorination

Chlorination protects water during storage. A reliable source of chlorine solution is necessary, and can be produced locally. Sodium hypochlorite at a concentration of 0.5% is the cheapest and most easily stored. It remains usable for 30 to 60 days and can be produced by various salt electrolysis systems, some of which use solar energy. The necessary quantity for water disinfection varies with the bacterial load and the turbidity of water. Analyses conducted in South and Central America showed that 0.5-1.5mg/L usually achieved disinfection<sup>9</sup>. Length of contact must be at least 30 minutes for chlorination to work. Problems posed by this technique include the necessity of either a large initial investment or of a reliable income to procure the solution, the risk of dosing error, a residual taste that is sometimes difficult to accept, and the risk to children if chlorine solution is stored within their reach.

#### Solar disinfection (SODIS)

This method's principle has been known since 1877, and has reemerged at the end of last century as a promising technique for water disinfection in the tropics<sup>10-13</sup>. It is based on the sterilization effect of UV radiation and heat. In a field study in Kenya using water massively contaminated by *Escherichia coli* (20x10<sup>5</sup> CFU/ml), it was shown to lead to a complete disappearance of viable germs in seven hours<sup>13</sup>. If the water reaches 45°C, a strong synergistic effect between heat and UV radiation is observed<sup>14,15</sup>. The use of solar sterilization has been shown to decrease the morbidity linked to infectious diarrhoea in children<sup>16</sup> and seems effective in inactivating *Vibrio cholerae*<sup>17,18</sup>.

Implementation consists of exposing water to the sun in plastic containers. In order to ensure sufficient penetration of UV radiation, these containers cannot be too wide. To increase the synergistic effect of heat, the side opposite the sun is painted black. The bottles can also be placed horizontally on a dark surface. Recycled 1 1/2L PET bottles (not glass) are appropriate. Time of exposure must be increased if there is no direct sunlight. Maximal effect also requires that the water be clear enough to read or see a small object through the bottle. However,

### Box 1 Water storage and handling

**Example 1 :** The user draws the water from a stone well using a plastic bucket. This well is covered with a metal sheet when not in use. In his home, the user pours the water into a black plastic jerrycan. This container is closed and used as a household reserve.

**Example 2 :** The user draws water from a pump-well into a closed plastic jerrycan. The well is on a small hill and the walk home will be about 15 minutes. Once home, he pours the water into an identical container, which is used as a household reserve.

**Example 3 :** The user draws water from a pump-well using an uncovered plastic bucket. Once home, he covers it and uses it as a household reserve. Water from earlier trips is stored in aluminium pans. Some of them are covered.

**Example 4 :** The spring is enclosed in concrete and covered with branches. Water pours through a plastic pipe to a small pond and the user lets it pour into a plastic bucket, which he then covers and uses at home as a household reserve.

**Example 5 :** Rainwater is collected under the open sky in a metal pan. It is stocked in the same container.

this technique can also function through heat alone if the temperature reaches 55°C<sup>13</sup>. Shaking the bottles periodically to increase the oxygen content of the water could increase its efficacy<sup>19</sup>. Like chlorination, it has the added advantage of allowing the sterilization of water to take place in containers that can be used for storage with no further manipulation.

#### *Hand washing*

Hand washing with soap and water after defecation and before handling food has been shown to reduce the incidence of infectious diarrhoea<sup>20</sup>. Enteric bacteria survive on hands for at least three hours and can be transmitted in many ways during this time<sup>21</sup>. This method has the advantage of targeting food-borne as well as water-borne diarrhoea. It does, however, require that sufficient quantities of water be available for hand washing.

#### *Modification of storage containers*

Human hands and houseflies are known vectors of bacterial contamination<sup>22</sup>. Thus, open containers are inappropriate to conserve the quality of water. Using safer containers is one way to protect water against contamination<sup>23</sup>. An ideal container must effectively protect water, and be easy to use. It must be of an appropriate size so it is not too difficult to carry when full. Recommendations for such a container by the US Center for Disease Control are summarized in Box 2. In addition, the material should be stable for outdoor use. Some plastics are not stable in ultraviolet light and can break after a few months if they are kept in the sun<sup>24</sup>.

The modification of storage containers can be combined with chlorination. The combined use of a closed container and longer contact times (>8 hours) can decrease the amount of chlorine necessary and, with it, the residual taste. Specially manufactured containers can also incorporate a system for dosing the chlorine solution. This combination has been shown to decrease the incidence of infectious diarrhoea by 44% and 50% in Bolivia and Nicaragua, respectively<sup>9,25</sup>.

#### *Shortening the "path of water"*

In one study, the factor with the strongest association to a decreased incidence of diarrhea was a short distance to the closest well<sup>26</sup>. Indeed, a tap in every home was shown to be the only effective way of substantially decreasing the incidence of schistosomiasis, but in resource-poor areas this is not a feasible solution in the short term<sup>27</sup>. However, there could be situations where quality at the source could be usefully traded off for proximity and quantity of the available water. Adaptation and protection of existing water sources is less costly than digging new wells and may be preferable in regions where water is abundant. This would shorten storage time, and increase the quantity of water available to households. Such conditions would make protecting water easier. It would also make it more likely that sufficient clean water be available for basic hygiene and hand washing. Another related aspect is the fact that pump-wells, although they are often presumed to be clean, can be contaminated<sup>6,28</sup>. This can lead to a false sense of security.

#### *Teaching*

Numerous calls for more teaching of health-oriented behaviours regarding drinking water have been made. Targeted teaching was shown to reduce the incidence of diarrhoea in several studies<sup>26,29</sup>. Several barriers, however, can hamper health-oriented teaching. First, health care professionals are rarely trained as teachers and can sometimes be remarkably inapt. Therefore, collaboration with professional teachers with field experience in the targeted area can be an important asset. If teachers are from outside the target community, cultural barriers can also raise problems. This difficulty can be minimized with the help of a "cultural mediator". This person should be sufficiently familiar with groups to be able to effectively assist good communication, sometimes regarding very personal matters.

Additionally, since it is rarely possible to teach an entire population, a target group must be selected. Because of their ready availability in schools, school-age children have been among the targeted populations. Their role as drawers of water and the impact they can have on its handling also make them a logical choice. They have also been shown to become effective teachers when asked to transmit what they have learned to their families<sup>30</sup>.

## Box 2 CDC recommendations for safe containers

- a stable base and handles
- a volume of 10 to 30 liters
- an opening with a diameter of 6 to 7.5 cm, wide enough to allow easy filling, but too narrow to allow immersion of utensils or hands
- a material that resists impact and oxydation, is easy to clean and transparent
- a tap, in a similar material, that closes easily and dispenses approximately one liter in 15 seconds
- a small valve or covered opening to allow air to enter as water is drawn from the tap
- instructions for use on a label affixed permanently in a waterproof form on the container
- a certification, also affixed on the container, either from the health ministry or from another appropriate authority.

Source 9

Women are another group traditionally chosen for health-oriented teaching due to their household responsibilities of cooking and collecting water.

### Conclusion

Our results confirm an important risk of bacterial contamination of drinking water between the source and the point of use in the district of Mfou. As long as sustainable development has not placed a clean water faucet in every home, increasing the safety of water storage and handling is vital. Efforts to purify water at the source, though valuable, are likely to remain of little use if mothers of children with diarrhoea are not given the tools to protect their household reserve from contamination during storage and handling. Techniques for safe water handling and disinfection at the point of use must be available and taught to at risk populations. Whenever possible, this should be tailored to individual situations on the basis of local bacteriological analysis of water and observation of water-handling behaviours. Bacteriological analysis and observation should also be used to assess the impact of interventions. Teaching is an important component of these efforts, however, its difficulties and limitations must be understood. Whenever possible, the help of experienced teachers should be enlisted in public health interventions. Collaboration with members of the targeted population is key to overcoming otherwise potentially overwhelming difficulties.

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