Abstract

Access to safe water is a major global challenge. WHO aims at ensuring it supporting actions for the improvement of water sources, but not always water from improved sources is really safe. Moreover water facilities are often located far from households, requiring collection and transport from the source to the point of use. All these steps are potentially source of recontamination. The study investigated water quality in Vilanculos, Mozambique, along the entire water supply chain to verify if drinking water from improved sources is safe. Then and identification of which are the causes of its deterioration took place.

Keywords: drinking water quality, Mozambique, water supply chain

1. Introduction

One of the major health problems globally are water-related diseases and the Joint Monitoring Program (JMP) reports that 783 million people in the world (11% of the total population) have no access to safe water. Target 7c of the Millennium Development Goals (MDGs) aims to halve the proportion of people counted in 1990 without sustainable access to safe drinking water and basic sanitation. The JMP has classified water sources into
‘improved’ and ‘unimproved’ categories as an interim measure of drinking water safety (WHO&UNICEF, 2010), and this is used as a simple indicator of access to safe drinking water, assuming that water collected from ‘improved sources’ is more likely to be ‘safe drinking water’ than water collected from ‘unimproved sources’ (Sorlini et al., 2012). Consequently, one of the major strategies for tackling this problem is the installation of protected sources such as boreholes, standpipes or wells to provide water of better quality. But ‘safe drinking water’ is defined by WHO as drinking water which ‘does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages’ (WHO, 2011) and not always improved sources provide safe water (Godfrey et al., 2011; Wright et al., 2004).

Moreover often water facilities are located far from households, requiring collection and transport from the source to the point of use. It has frequently been observed that the microbiological quality of water in buckets in the home is lower than that at the source, suggesting that contamination is increasing during collection, transport, storage and drawing of water (Wright et al., 2004) and this re-contamination decreases the benefits of water source improvements.

2. Objectives

The objective of the present study is to analyse the drinking water quality in Vilanculos (Inhambane Region, Mozambique) both in the improved and in unimproved water sources. Water was analysed at the source and at the point-of-use to investigate which factors mostly affect the recontamination along the water supply chain before the final consumption.

3. Materials and methods

3.1. Study area

The study area is the municipality of Vilanculos located in the region of Inhambane (south Mozambique). Vilanculos is a small town of 50,000 inhabitants and characterized by some basic services such as public transportation system that run in the main roads and the aqueduct that supplies almost 50% of the municipal population through public fountains and private taps (placed in the lot, outside the house).

The remaining population uses other types of sources as open wells (public or private, protected from parapets of cement, tin or tires, with depths ranging from 3 m up to 30 m) and protected wells equipped with electric pump or hand pump. Finally regarding wastewater managment, Vilanculos is widely provided (80%) by traditional latrines located in each home.

3.2. Water quality indicators

WHO guidelines for safe water state that no fecal indicators should be present in a 100 mL sample, and Mozambique, through the Ley de Agua and later regulations (2004), follows consistently these guidelines, imposing the absence of many (but not all) micro-organism indicators of fecal contamination in the water for drinking purposes. The present study investigated the microbiological contamination of drinking water sources based on the presence of \textit{Escherichia coli} and \textit{Faecal streptococci}. 

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3.3. Water sampling and microbiological analyses

The monitoring campaign took place between August and September 2013. In the field work some households of Vilanculos have been visited to collect drinking water samples, one at the source and one at the point of use. Water samples were then analyzed to determine microbiological contamination. The goal was the creation of a map of water sources and related quality and the identification of the factors that most influence the quality along the supply chain from the source to the point of consumption.

3.4. Questionnaires

The same families were interviewed by means of a questionnaire to gather information about the water supply system, the financial capacity to have an improved source access, the sanitation facility used (if any) and their hygiene habits. The aim was to characterize the water supply chain to identify the factors that impact on the recontamination of the water after the collection at the source, through transport and storage.

4. Results and discussion

In this study 116 water points were analyzed: 32% were open wells, 21% protected wells (equipped with hand pump or electric pump), 7% public fountains and 40% of private taps. Table 1 shows the number of water points analyzed and the related water quality.

<table>
<thead>
<tr>
<th>WATER SOURCE</th>
<th>N</th>
<th>E.COLI (UFC/100mL)</th>
<th>ENTEROCOCCI (UFC/100mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public open well</td>
<td>4</td>
<td>127 (5-600)</td>
<td>1513 (15-5500)</td>
</tr>
<tr>
<td>Private open well</td>
<td>34</td>
<td>372 (10-5000)</td>
<td>1768 (150-9300)</td>
</tr>
<tr>
<td>Protected well equipped with hand pump</td>
<td>13</td>
<td>12 (0-230)</td>
<td>39 (0-300)</td>
</tr>
<tr>
<td>Protected well equipped with electrical pump</td>
<td>11</td>
<td>5 (0-45)</td>
<td>261 (0-1000)</td>
</tr>
<tr>
<td>Public fountain</td>
<td>8</td>
<td>0 (0-2)</td>
<td>34 (0-100)</td>
</tr>
<tr>
<td>Private tap</td>
<td>46</td>
<td>2 (0-21)</td>
<td>59 (0-400)</td>
</tr>
</tbody>
</table>

The major difference among the contamination of unimproved (open wells) and improved water sources (piped water and protected wells) brought to analyze separately these two different categories (unimproved and improved sources). Water quality from unimproved sources did not significantly vary along the supply chain: deterioration occurs in about 50% of cases, in 30% of cases did not change and in 20% of cases an improvement was even observed. This behavior was also highlighted in the case studies analyzed by Wright et al. (2004). In this specific research, the cause was probably to be due to the sedimentation phenomena developed inside the containers for domestic storage, which contributed to the microbes decrease.

In the case of improved sources a significant deterioration in water quality appeared along the supply chain. It was possible to observe the deterioration of water quality from source to point of consumption, observing the percentage of samples conformed to the regulatory limits (0 CFU/100mL). As an example, Fig. 1 reports the percentage of compliance from the source to the point of consumption referring to *Escherichia coli*, along the water supply chain of piped water. Based on the results obtained, it has been chosen to
analyze only for improved sources (78 cases), the correlation between the levels of re-
contamination along the water chain and hygiene and household water management habits.

![Piped water - E.coli](image)

**Fig. 1.** Percentage of conformity of piped water with the national water law along the water chain

It was therefore analyzed the magnitude of re-contamination in relation to several factors, characterizing the transport and storage of water, considered relevant to verify the effect that each of them assumes in the re-contamination process. For the transport step the impact of the type of container used and the ownership of the source was evaluated. For the domestic water storage, the incidence of hygiene practices concerning the location and protection of the container used was analyzed.

A preliminary analysis revealed that the ownership of the source is the factor that most affects the re-contamination process of drinking water. For this reason, all other factors were investigated dividing the samples in two categories: families with the ownership of the source (45 cases) and families without ownership (33 cases).

It was found that in the two categories and both in transport and storage steps, the practice that more influences the water recontamination and is the habit of keeping the containers open (with respect to the type of container and its location). Even this result confirms the ones found by Wright et al. (2004).

5. Concluding remarks

The study focused on the analysis of drinking water quality from the source to the consumption point in Vilanculos.

Water resulted contaminated at all water sources, even if more in unimproved sources. The causes could be attributed to the lack of sources protection and the high contamination level of the soil due to the lack of good sanitation practices.

The major factors influencing negatively the drinking water quality along the supply chain were the ownership of the water point and the habit to cover the containers used for transport and storage. This demonstrates the importance of supporting the structural improvements of water points with hygiene promotion activities.

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References


