COMPARISON OF MICROBIAL QUALITY OF WATER SOURCES AND HOUSEHOLD WATERS IN RURAL WESTERN KENYA; AN INDICATOR OF HYGIENIC HABITS?

P.O.Lehmusluoto, University of Helsinki, Ristiniementie 32 K, SF-02320 Espoo, Finland

Introduction

In recent issues of Waterlines, water quality in conjunction with some water supply and sanitation projects has been discussed. Especially interesting were the two articles describing water quality in the rural areas of the Western Province of Zambia.[1,2]

In the findings water sources were fairly uncontaminated, and the household waters were usually not further contaminated during transportation and storage, contrary to many other studies. This was said to indicate the local perception of clean water and hygienic habits.[2] It may be considered to be one of the few successful projects in the true spirit of the Mar del Plata convention, safe water for all - not only at the source but also in the household at all stages of use. In the study it was also stated, that it is often assumed that deterioration in quality will take place after drawing. Unfortunately, this assumption seems to be a common reality contrary to the Zambian case. There are several actual cases reported, including this study. [3,4,5]

According to the Mar del Plata resolution, all should have safe water by 1990, but there has been some ambiguity in its interpretation. Generally, it has been emphasized, that people should have access to a safe water source in their neighborhood. Usually this can be arranged technically, if enough funds are available. The technical solutions may also be replicable. However, to preserve the supplied water unpolluted and uncontaminated before use is a social task, which deals with human habits and behavior, and its replication is difficult. The decade slogan "safe water for all" was in many occasions converted to "safe water supply for all".

Situation in Western Kenya

This study looks at the microbial water quality in rural areas of the Western Province of Kenya. At the time of the study, the water supply and sanitation projects were at their inception stages. Both projects were complemented with e.g. health education activities.

There was no prior information available to which extent the existing water supplies and waters used in the households were contaminated. A commonly raised question by the people was, is the water safe to be used after the water supply has been improved? There seemed to be the prejudice, that pumped water is always safe. This, nonetheless, is only partly the case. The water sources may not, even after improvements, be entirely safe, and during drawing, transportation, storage and handling contamination often occurs. This contamination is dependent on the general hygiene habits of the people, as noted above.

The question, which contamination is more hazardous, contamination of the water sources or waters used for drinking and other household purposes are continuously springing up. The extent of the consequences of contaminated sources depends on the number of people using the sources, and the extent of consequences of contamination of household whether water is used within the household itself or by frequent visitors from other households and neighboring villages use it. However, luckily, there are only a few diseases that are strictly water borne. A great majority is dependent on the prevailing hygienic conditions and practices.

Study Areas

The study areas in the Western Province of Kenya were Elukongo and Moding sublocations (Figure 1). The area of the Elukongo sublocation is 37 km^2, population 7,700 (1979) and population density

203 persons/km^2. The respective figures for Moding sublocation are 29 km^2, 6,000 and 177 persons/km^2. The Population density in Kenya was 27 persons/km^2 (1979 census).

Kenya had, according to the 1979 census, an estimated crude death rate of 14 ‰ and an infant mortality rate of 115 ‰ of live births. About one half of all the deaths in Kenya occur among the children under the age of five. The major proportion of the diseases has been water related. However, it has also to be remembered that most episodes remain unreported and unrecorded.[6]

The main water sources in Elukongo were springs (93 %) and wells (6 %), and in Moding, springs (72 %), wells (15 %) and rivers (12 %). In addition, dams were utilized. There were only two boreholes, one in each of the sublocations.[7]

In Elukongo sublocation, 60 unprotected springs, 26 protected springs, 4 shallow wells, the only borehole and 189 household containers were examined. For Moding sublocation, the respective figures are 18, 7, 2, 1 (the only one) and 27. The total number of unprotected springs examined is thus 78, of protected springs 33, of shallow wells 6, of boreholes 2 and of households 216.

Almost all the water sources (95 %) and a large proportion of the households (82 %) in Elukongo, and in Moding slightly over half (65 %) of the water Sources and about 16 % of the households were visited. In Elukongo sublocation there are altogether 19 villages and in Moding sublocation 8 villages. The water sources and households visited should give a general idea of the conditions in the sublocations.

The general sanitary situation was relatively good in both of the sublocations. In Elukongo 49 % and in Moding 61 %, of the households had pit latrines.

Microbial quality of water

The microbial quality of waters was examined as faecal coliforms (FC) by the membrane filter technique using the Endo-type medium provided by Sartorius GmbH (former FRG). Due to the limited number of samples, and lack of parallel and seasonal samples, the results do not have high statistical significance. The same applies to almost all similar studies.

The contamination of waters is generally interpreted and judged according to the international guidelines given for recent introduction of faecal matter (faecal contamination) and for susceptibility of pathogens present in water. The guidelines indicate the suitability of waters for human consumption.[8,9] The basic principle is that water sources, but naturally also household waters, should neither contain any coliform organisms nor any faecal coliforms at any given time. If one or more FCs is present in water, it is considered as susceptible.

For practical reasons the results of this study have been grouped into four categories; < 1, 1-10, 11-100 and > 100 faecal coliforms/100 ml of sample water.[4] This does not affect the overall scope of the study, but may, instead, highlight some of the important outcomes of the results.

The international interpretation and judgment criteria may, however, in many aspects be impracticable and unsuitable for the rural areas where the majority of water sources are springs, wells, boreholes, dams and rivers and not piped water supplies.[10] If the international standards will be applied there will be a large number of noncompliance cases, which is not a goal *per se*. Therefore, it might be reasonable to set such targets over a long period of time, and the immediate measures should be concerted on the general hygiene practices at household and village levels to protect water sources and water itself from contamination at every stage of consumption.

In each operational area guidelines, which shall take into consideration the available water resources, accessibility to the sources, local habits and especially the local health situation could be the basis to begin with, and the guidelines reviewed periodically by the local authorities.

Results

The individual results were arranged into four categories, as mentioned earlier. The results are shown in Table 1.

Table 1. Contamination of water sources and household waters (EL = Elukongo, MO = Moding and Av. = Average).

a. Water Sources

Source	Contamination											
	< 1			1-10			11-100			> 100		
	EL	MO	Av.	EL	MO	Av.	EL	MO	Av.	EL	MO	Av.
Unprotected springs	33	22	28	67	78	73	40	67	54	23	56	40
Protected springs	54	43	49	46	57	52	19	43	31	8	29	19
Shallow wells	25	0	13	75	100	88	25	100	63	0	50	25
Boreholes	100	100	100	0	0	0	0	0	0	0	0	0

b. Household Waters

Source	Contamination											
	< 1			1-10			11-100			> 100		
	EL	MO	Av.	EL	MO	Av.	EL	MO	Av.	EL	MO	Av.
Unprotected springs	9	7	8	91	93	92	75	93	84	60	71	66
Protected springs	15	13	14	85	88	87	73	63	68	58	25	42
Shallow wells	11	0	6	88	100	94	77	100	89	33	50	42
Boreholes	0	0	0	100	99	100	75	66	71	75	0	38

The presentation may be feasible bearing in mind the fact, that sampling was carried out only once for each source and household (with only three exceptions). Neither diurnal nor seasonal variations could be observed.

Contamination of water sources

a) Unprotected springs

A major proportion (about 78 %) of the unprotected springs in Moding did not comply with the international standard of < 1 FC/100 ml. If we consider 10 FC/100 ml as an operational guideline for the two sublocations, about 67 % of the results still exceeded this limit value in Moding. There were, however, also some uncontaminated unprotected springs. In Figure 2, a typical unprotected spring in Moding is shown.

In Elukongo about 67 % of the unprotected springs did not comply with the international Standard and about 40 % with the operational guideline. However, in Elukongo about 33 % of the unprotected springs were uncontaminated.

b) Protected springs

It is evident that protected springs do provide in most cases safer water that the unprotected ones. In Moding area about 43 % of the protected springs were uncontaminated while in Elukongo about 54 %. However, there were protected springs that were heavily contaminated. In Moding in about 29 %[1] and in Elukongo about 8 % of the springs were more than l00 FC/100 ml and about 43 % and 19 %, respectively, in excess of 10 FC/100 ml. In Figure 2, two old and unmaintained protected

[1] In Moding, the spring protections were old and they needed rehabilitation or maintenance.

springs in Moding are shown.

c) Shallow wells
In both of the sublocations, there were only a few shallow wells. In Moding, the householders constructed them and they could be considered as pits (unlined). They were also old and in rather bad shape. In Elukongo, the Rural Water Supply Development Project (RWSDP) recently constructed the shallow wells. They were lined. Shallow wells in Moding were open whereas these in Elukongo were covered with concrete slabs and were provided with hand pumps.

In Moding in all the shallow wells was more than 10 FC/100 ml while in Elukongo in the majority was less than 10 FC/100 ml.

d) Boreholes
At the time of the study, there was only one borehole in each of the sublocations. Both of them were uncontaminated. In Figure 2 is shown the borehole in Elukongo equipped with solar pump and storage facilities. The solar system gives electricity also to the local health center.

Contamination of household waters
There may be several factors affecting the water quality and contamination after it has been drawn from a water source. Some may reduce and scan may increase contamination. The overall effect can best be observed in the household water containers.

Generally, waters used in households in Moding and Elukongo sublocations were grossly contaminated, in about 93 % of them was more than 1, in about 78 % more than 10 and in about 47 % more than 100 FC/100 ml.

Discussion
There was seemingly no marked difference in the degree of contamination of the waters in the household containers. Thus the microbial quality of the source, whether an unprotected or protected spring, a shallow well or a borehole, did not seemingly significantly affect the contamination at household level. In order to be able to draw any further conclusions there should be more data throughout the year, but evidently the strive to improve water supply does not alone solve the serious disease problems.

As we know, there are four main mechanisms through which water can be related to disease transmission; namely water-borne, water-washed, water-based and water related insect vector mechanisms.[11,12,13] A fifth mechanism shall also be mentioned, although it is not directly water related; faecal-disposal mechanism which is usually due to defective sanitation and insufficient general and personal hygiene. It may, however, be of great significance in disease transmission. Its role is important and its recognition is vital in planning intervention strategies.

Although there were no possibilities to re-examine the water sources and households during different seasons, the results may give an idea of the situation in the two sublocations.

In Figure 3, the microbial contamination of the four types of water sources and household waters drawn from them is presented. According to the results, it is evident that water drawn from a source is in most cases contaminated on its way, or in the house, although the majority of the household containers were covered with a lid. There are also studies of piped schemes with similar indications.[14]

As seen in Figure 3, there were no marked differences in contamination of household waters

whether drawn from unprotected springs, protected springs, shallow wells or from boreholes, contrary to the observations made in Zambia.[2] About 28 % of the unprotected springs in both of the sublocations were uncontaminated, but only 8 % of the waters drawn from them were uncontaminated in the household containers. About 49 % of the protected springs were uncontaminated, but only 14 % of the household waters were uncontaminated. The respective figures for the shallow wells are 13 % and 6 % and for the boreholes 100% and 0 %. In the other categories, the pattern of contamination of water sources and household waters was quite the same, except in the case of the two boreholes. Both of them fell in the category of < 1 FC/100 ml, but none of the household waters drawn from then were in that category.

It has especially to be noted that the majority of the household waters, in spite of evaluating them according to the operational guideline value of more than 10 FC/100 ml, did not comply with the guideline value (see Figure 3).

Boreholes have clearly been the best sources. The second best sources were protected springs. Protected and unprotected wells (shallow wells) and unprotected springs had the lowest quality of water. The same kind of tendency can be observed from the results of the RWSDP in the Western Province. It is worth mentioning that especially in Moding unprotected springs, broken spring protections and open shallow wells (pits) may also be contaminated by the drawer.

According to the results, the degree of contamination after collection has been especially high for waters drawn from boreholes, although the households have had the benefit of safe, uncontaminated source. It may be anticipated that people have been led to believe that pumped water is equivalent to "maji safi" (safe water), and they may have disregarded the necessary hygienic habits.

The difference of contamination of the source and of the water in the household container could be a good indicator of the general environmental sanitation conditions as well as public and personal hygiene practices. In Zambia, the authors considered that the credit for the minimal contamination between drawing and use should be given to the good practices.[2]

The above could also imply that the types of water sources may not, at present, affect the levels of contamination of the household waters. The case of boreholes clearly demonstrates this. Although the general inadequate environmental sanitation conditions and hygienic practices are interfering the progress, and the funds used for improvements may thus be considered partly “wasted", this should not lead to discouragement of rehabilitation and improvement of the water supplies. However, the "appropriate" and "least cost technology" could give the same benefits as the more "advanced technologies". This may prove important in providing water closer to the users and in promoting increased use of water by the households.[15]

There were no clear patterns to explain the area differences of contamination. The newly improved water sources and new water supplies were partly introduced in these areas, but these water supplies were not markedly less contaminated than those in the other villages. However, due to the numerous springs, the accessibility may have been better and hence the volumes of water used may have been greater.

Beneficiaries and benefits

Although the populations to be served by the improved water supply have been considered to be affected, there are clear indications that they do not benefit in full of the safe water provided by the new facilities. This may be partly due to the contamination of the water by the acts of people. Eradication of this kind of negligence in the use of the provided safe water is a social problem,

connected to the habits and behavior of people.

Provision of uncontaminated water does not have all the anticipated effects, and the results do not necessarily correspond to the efforts and funds. The approaches should need complementary concepts beyond the technical components. There are several transmission routes of diseases and thus there should also be several major control practices, of which one is provision of good quality water. However, a filthy community, of which the contamination of the provided water before use is a sign, may make this provision partly questionable.

As a whole it can be emphasized that, the control of diseases is complicated and cannot be achieved by technical means alone. Such factors as human behavior patterns, lack of education, crowding, poverty and lack of basic understanding of communal, household and personal interventions may over-ride the proven health enhancing potential of even distribution of safe water. There were such implications in Elukongo and Moding sublocations. Thus, it may be optimistic in any project design to assume, that a definite reduction of episodes of diseases can be directly attributed as an indicator of change caused by the rural water supply projects, as e.g. the Finnish International Development Agency has suggested.[16]

If we consider the situation in Elukongo and Moding sublocations, the recent surveys do not allow speculations of the possible health impacts of the very recent interventions. The remarks are given, bearing in mind that though not fully complete, without subsequent action plans the information is futile, and also bearing in mind that the information available should be continuously supplemented and, accordingly, the action plans amended.

Conclusions

The results of the survey indicate that a great deal of water sources is contaminated. The results also indicate that the contamination introduced during transportation and storage tends to be shed by the water collectors or by other household members. Thus, water should not be considered in these cases as the sole primary transmitter of diseases. The risk of any particular level of contamination of such household waters may, however, be lower than if associated with a water source. This fact, however, highlights e.g. the importance of sanitary practices. Their promotion in juxtaposition of improved water supplies, which does not necessarily lead to increased water use, would be of great importance, because increased water use is one of the important mitigation factors.

In Elukongo and Moding, there are a good number of perennial springs scattered around. Most of them are unprotected, and a great deal of them is presently contaminated. They are especially susceptible during epidemics. If properly protected these could provide a good coverage of protected springs compared to the ground water sources. The second choice could be boreholes, if spring protections are not feasible or the springs are not perennial. According to the survey even the protected shallow wells did not, largely, act as safe water sources. This is partly due to the unsatisfactory design and construction practices. Some of them also tend to dry up during dry seasons diverting people to traditional sources, which is not commonly advisable. The problem of drying up could be avoided if the shallow wells are constructed only during the dry seasons.

The provision of protected springs is a cost effective solution with reasonably good effects in reducing contamination and thus, if proper hygiene practices are administered, in abating possible diseases transmission. Neither do the spring protections interfere with the deeper groundwater.

The open shallow wells (pits) in Moding are often subject to the similar contamination patterns as the unprotected springs. The number of such water sources was, however, low. The protected

shallow wells in Elukongo seemed to be less contaminated than the open wells in Moding, but more contaminated than the protected springs.

The surprising lack, or inadequacy of examination of microbial water quality, especially of household waters actually used by people, may indicate the common faith in the technical interventions and in their believed direct effects. The microbial contamination of the household waters may act as an indicator of all the combined efforts or deficiencies for safe water supply. Its monitoring should be continuous and frequent enough to allow statistically significant conclusions, contrary to the indicative ones e.g. in this survey.

However, it should be kept in mind that longitudinal average values do not reflect the actual situation at any given time, and the actual values are the values, which matter in considering disease transmission.

In addition to new schemes rehabilitated existing water sources would be an additional and affordable asset, because the number of people in relation to the number of new water sources is, almost always, too high for efficient water fetching and the fetching distance remains too long.

In the Zambian case, it was likely, as mentioned earlier, that people were aware of the quest of the hygiene habits and practices, while in the Kenyan case there was much to be hoped for. Comparison of contamination of the sources and the household waters may give an indication of hygiene practices and could thus well be a part of a sanitary survey. However, this kind of "impact" studies, including this, have generally been underrated and discouraged, although the households are important and effective tools in achieving the actual goals of the Mar del Plata resolution, which were not technical. This has now been, after the decade, underlined also in the New Delhi statement.

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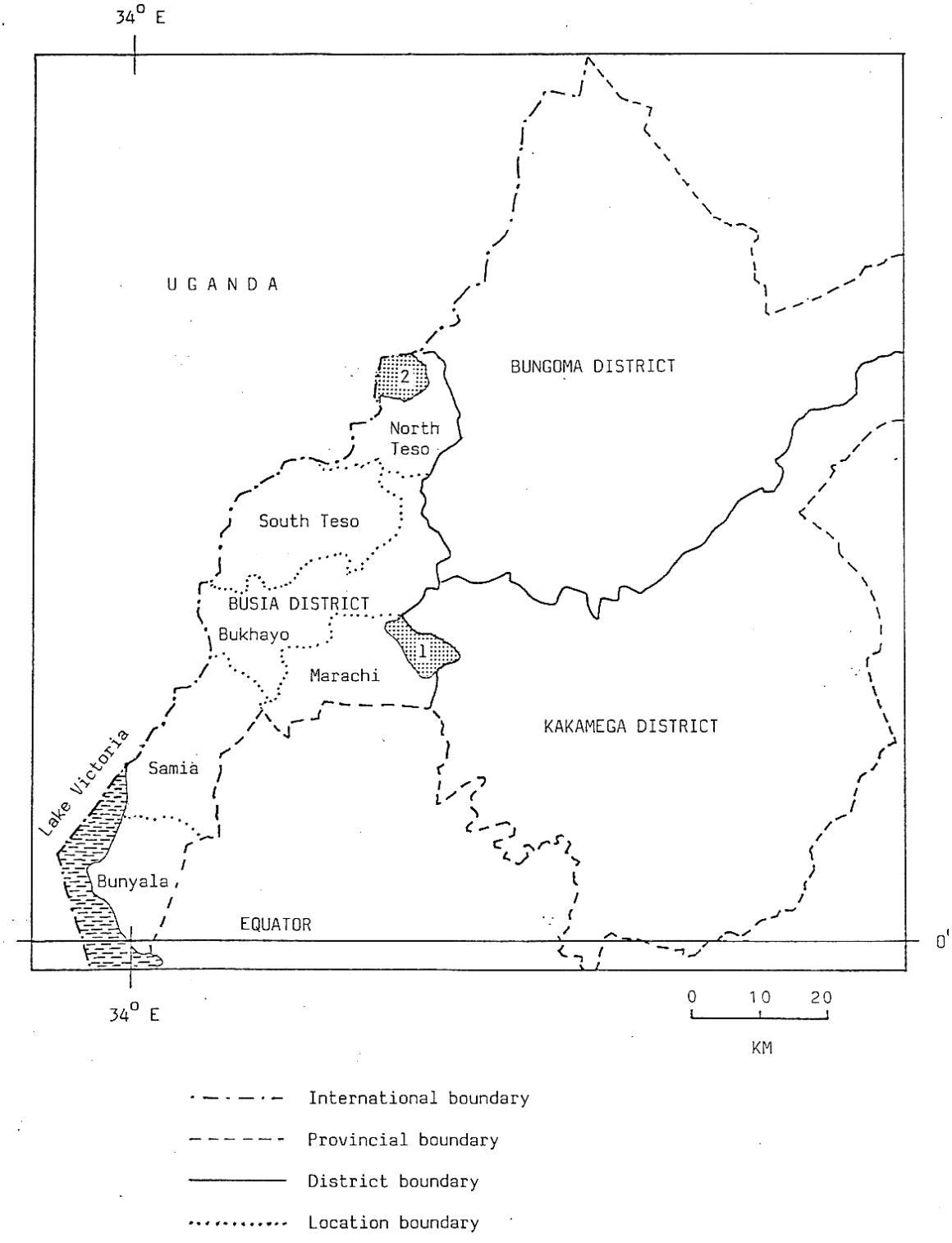

Figure 1. Map of the Western Province of Kenya with locations of Busia district. The study areas are dotted on the map. Elukongo sublocation is marked as 1 in Marachi location and Moding sublocation is marked as 2 in North Teso location.

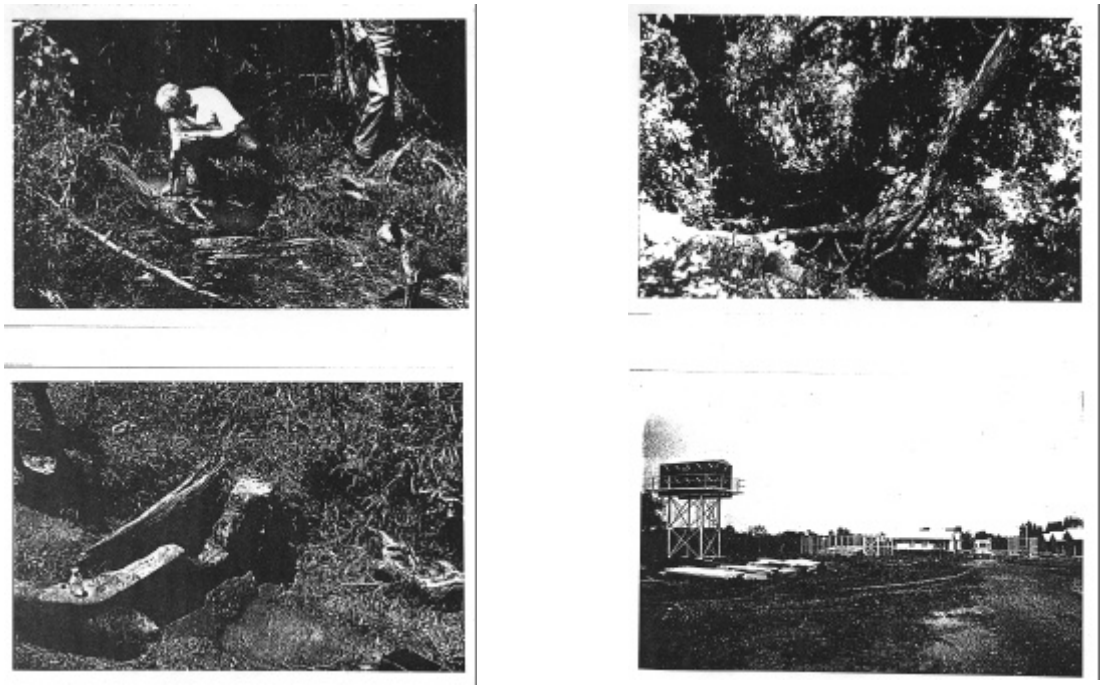

Figure 2. A typical unprotected sprig (upper left corner), typical old and unmaintained spring protections in Moding sublocation (lower left and upper right corners), and a modern borehole in Elukongo sublocation at Bumala B health center equipped with solar pump and storage tank (lower right corner).

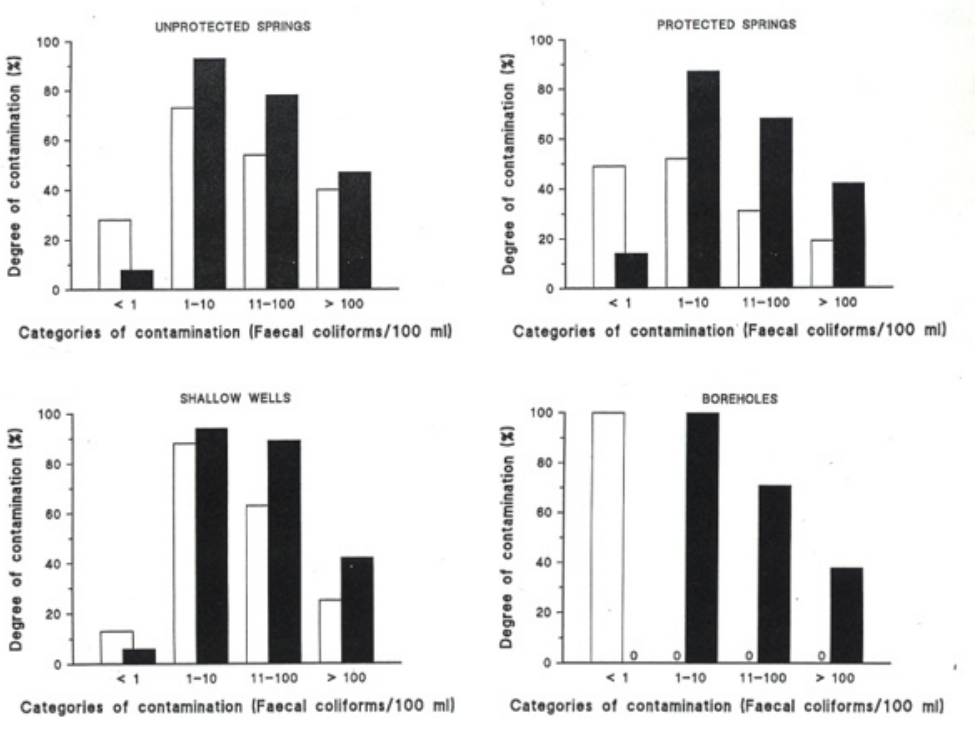

Figure 3. Microbial contamination of water sources and household waters drawn from the respective sources in Elukongo and Moding sublocations. Contamination is presented as percentage of all the samples (see Table 1). The open bars represent water sources, the solid bars household waters and zeros denote, that no results were in those categories.