Well Water Survey in Kaloko, Copperbelt District, Zambia

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Introduction

This study was conducted in a joint project by The Global Dry Toilet Club of Finland and the Kaloko Trust Zambia. The aim of the study was to analyze the bacteriological quality of the well and stream water in the region by using chromogenic count plates. The results from the study will be utilized as part of the dry sanitation project.

Study sites

All study sites were located in the Kaloko trust catchment area, in a 20 km. radius from the Kaloko village, excluding the Chief's Palace, which is located in Maisaiti, approximately 50 km. from Kaloko.

Methods

The water analyses were conducted in rural areas of the republic of Zambia, namely the Kaloko in Masaiti district. The samples were collected in two different occasions, firstly in a three week period in the end of dry season, in the end of December (05 – 22.12.2006) and secondly in a one week period during the rain season in the beginning of the February (06-10.02.2007). Due to the unavailability of electricity and adequate research facilities, the methods were adjusted to local conditions and suitable *in-situ* analysis methods were selected.

Bacteriology

Total coliforms and E.coli were analyzed by using chromogenic plate count for their detection, namely Compact Dry EC, manufactured by NISSUI Pharmaceutical CO., LTD.

Bacteriological tests were conducted from the same sample water from which physicochemical parameters were determined. All samples were handled with plastic disposable 1 ml. Pasteur-pipettes, one used only for one sample, and clean vinyl gloves were used to minimize the risk of contamination.

The used method was to produce two homogeneous plates from the sample, both containing 1 ml. of the sample solution. These plates were then stored in a Styrofoam box equipped with a thermometer and incubated in a variable temperature of 25-35 C for 48 h. The colonies were counted once after 24 h. and after 48 h. the final count was taken. Both total coliforms and E.Coli (along with E.coli 0157) were determined from the same plates as they form colonies of different colour. Results from the final count were averaged and the mean was multiplied with 100 to achieve general reporting units for bacteria's (col./100ml) (WHO).

Sampling

To get a representative sample of the water being consumed, the sample was collected by using the same methods and equipments as the locals do. The samples were taken directly from the source or collected in plastic bottles of 1 l. volume, each rinsed three times with the water to be tested. All samples were studied *in-situ*. However, all bacteriological analyses started within two hours from collection.

Physico-chemistry

The temperature of the sampled waters was measured with an electronic temperature meter and pH with Hanna Instruments Hanna Checker 1 tester (HI 98103).

All equipment was cleaned before and after they were used for analysis by using distilled water. The pH meter was calibrated always before analysis, by using a two point calibration method with appropriate buffer solutions (pH 4. 01 and 7.01).

Results

The results from the analyses are presented in tables 1 and 2. Results from different types of sources are grouped to simplify comparison.

Table 1. Results from the first samplings

Parameters	Units	Types and Locations										
		BH	MW		TW					WP	Streams	
		Kaloko	Chisapa	ChiefsPalace	Mwaitwa	Serenje	Kwesha	Kandulwe	Kasamwa	Lumombwe	Luampesa	Luankuni
Temperature air	(°C)	28,9	29,3	22,3	24,7	22,0	30,2	31,3	25,7	31,2	27,1	25,0
Temperature sample	(°C)	24,6	24,3	24,3	23,5	23,0	22,2	23,5	23,8	27,0	21,1	22,6
pH		6,67	6,52	6,13	6,20	6,80	6,32	6,12	5,60	6,47	6,82	6,87
Total coliforms	(col/100 ml)	900	50	1100	3550	28400	14400	10350	7350	17200	14250	31700
E.coli	(col/100 ml)	–	–	–	150	300	350	50	50	350	1000	1700
of which E.coli 0157	(col/100 ml)	–	–	–	–	–	–	–	50	150	400	350

Table 2. Results from the second samplings

Parameters	Units	Types and Locations										
		BH	MW		TW					WP	Streams	
		Kaloko	Chisapa	Chief's Palace	Mwaitwa	Serenje	Kwesha	Kandulwe	Kasamwa	Lumombwe	Luampesa	Luankuni
Temperature air	(°C)	–	28,2	28,8	28,2	26,6	31,5	30,2	29,9	29,4	30,8	30,0
Temperature sample	(°C)	–	24,7	25,1	23,9	23,3	23,5	23,5	24,7	26,8	23,5	22,8
pH		–	6,54	5,82	5,38	6,60	6,37	6,37	5,20	6,28	6,67	6,80
Total coliforms	(col/100 ml)	–	200	300	26950	16300	18650	4000	18500	8300	17700	18000
E.coli	(col/100 ml)	–	–	–	1100	450	150	50	200	300	700	200
of which E.coli 0157	(col/100 ml)	–	–	–	1000	450	50	50	200	300	250	–

Borehole

Water in the analyzed borehole (BH) (Kaloko) was found of good quality with only a small (900 col/100 ml.) bacterial contamination was found from the sample. Borehole was only tested once due to the technical problems with the pump. The pH in the borehole was 6.67, which is in the satisfactory level and typical for groundwater.

Modernized wells

Two modernized wells (MW), built by Zambian government were tested. The wells are constructed by covering the well and surrounding area with a solid concrete platform. Both wells were equipped with hand pumps, and excess water was guided away from the platform.

The found bacterial contamination in the both wells was minimal comparing other tested water sources, excluding Kaloko borehole, and especially water in Chisapa well had excellent quality in terms of bacteriology.

The pH in both sampled wells of this category was between the ranges of 5.82 – 6.54, which is of satisfactory level.

Traditional wells

The traditional wells varied in design from simple unlined and uncovered holes to ones lined with concrete rings and covered ones, with the common denominator being that the water was lifted with a plastic container fitted with a rope.

The pH in all the sampled wells of this category was between the ranges of 5.20 – 6.80, which is of satisfactory level.

Bacterial contamination was found from all traditional wells, with maximum in December 2006 being 28 400 col./100 ml in Serenje and minimum 3550 col./100 ml in Mwaitwa. However, in February 2007 the maximum ratio was found in Mwaitwa being 26950 col./100 ml and minimum in Kandulwe being 4000 col./ 100 ml.

Water pit

The tested traditional water hole was located in Lumombwe. The bacterial maximum contamination in the water pit was found in December 2006 being 17 200 col./100 ml and minimum 8300 col./100 ml in February 2007 during the rain season. However, in February 2007, the E.coli 0157 was count was doubled from readings in December 2006 to 300 col./100 ml.

The pH in all the sampled wells of this category was between the ranges of 5.20 – 6.80, which is of satisfactory level.

Streams

Water from two streams, Luankuni and Luanpesa, was tested. High bacterial contamination was found from both streams, with maximum in December 2006 being 31 700 col./100 ml in Luankuni and minimum 14 250 col./100 ml in Luanpesa. February 2007 the maximum ratio was found in Luankuni being 18 00 col./100 ml and minimum in Luanpesa being 17 700 col./ 100 ml.

The pH in both streams was between the ranges of 6.67 – 6.87, which is of satisfactory level.

Conclusions

The results of this study show a widespread bacteriological contamination in the waters that households are using. The water sources in the area vary widely, as some villages do not have a functioning well at all and the water is carried from long distances. Generally the quantity of water is as much of an issue, as is the quality.

There were many structural differences between the sampled wells. The traditional wells were generally unprotected and built by digging a deep hole in the ground. In some cases wells were lined with concrete rings but the superstructure was allowing the runoff water enter back inside well. The wells built by Zambian government were well designed and protected from runoff water.

The study showed that water quality changes between dry and rain season. In some cases, like in Luankuni stream, the water quality improved remarkably, but like in Mwaitwa, the total coliform and E.coli contamination eight folded.

APPENDIX: Water data log

Date: 05.12.2006

Sample site: Kandulwe

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	31.3	23.5	6.12	99	1	-
B				109	-	-
				$\bar{x}$ 104	0,5	-

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	10400
E.coli (col/100 ml)	50
of which 0157 (col/ 100 ml)	-

Date: 08.02.2007

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	30,2	23.5	6.37	32	1	1
B				48	-	-
				$\bar{x}$ 40	0,5	0,5

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	4000
E.coli (col/100 ml)	50
of which 0157 (col/ 100 ml)	50

Sample site: Lumombwe
Date: 05.12.2006

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	31.2	27	6.47	249	1	-
B				102	6	-
				$\bar{x}$ 175.5	3.5	-

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	17550
E.coli (col/100 ml)	350
of which 0157 (col/ 100 ml)	-

Date: 10.02.2007

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	29.4	26.8	6.28	74	5	5
B				92	1	1
				$\bar{x}$ 83	3	3

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	8 300
E.coli (col/100 ml)	300
of which 0157 (col/ 100 ml)	300

Sample site: Mwaitwa
Date: 12.12.2006

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	24.7	23.5	6.20	25	2	-
B				46	1	-
				$\bar{x}$ 35.5	1,5	-

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	3550
E.coli (col/100 ml)	150
of which 0157 (col/ 100 ml)	-

Date: 10.02.2007

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	28.2	23.9	5.38	290	11	10
B				249	11	10
				$\bar{x}$ 269.5	11	10

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	26 950
E.coli (col/100 ml)	1100
of which 0157 (col/ 100 ml)	1000

Sample site: Kasambwa
Date: 12.12.2006

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	25.7	23.8	5.60	93	1	1
B				48	-	-
				$\bar{x}$ 73.5	0.5	0.5

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	7350
E.coli (col/100 ml)	50
of which 0157 (col/ 100 ml)	50

Date: 10.02.2007

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	29.9	24.7	5.20	154	-	-
B				207	4	4
				$\bar{x}$ 180.5	2	2

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	18 500
E.coli (col/100 ml)	200
of which 0157 (col/ 100 ml)	200

Sample site: Serenje
Date: 14.12.2006

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	22	23	6.80	284	3	-
B				unreadable	unreadable	unreadable
				$\bar{x}$ 284	3	-

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	28400
E.coli (col/100 ml)	300
of which 0157 (col/ 100 ml)	-

Date: 08.02.2007

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	26.6	23.3	6.60	154	4	4
B				172	5	5
				$\bar{x}$ 163	4,5	4,5

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	16 300
E.coli (col/100 ml)	450
of which 0157 (col/ 100 ml)	450

Sample site: Chisapa
Date: 14.12.2006

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	29.3	24.3	6.52	-	-	-
B				1	-	-
				$\bar{x}$ 0.5	-	-

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	50
E.coli (col/100 ml)	-
of which 0157 (col/ 100 ml)	-

Date: 06.02.07

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	28.2	24.7	6.54	1	-	-
B				3	-	-
				$\bar{x}$ 2	-	-

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	200
E.coli (col/100 ml)	-
of which 0157 (col/ 100 ml)	-

Sample site: Kaloko borehole
Date: 19.12.2006

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	28.9	24.6	6.67	9	-	-
B				-	-	-
				$\bar{x}$ 9	-	-

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	900
E.coli (col/100 ml)	-
of which 0157 (col/ 100 ml)	-

Sample site: Chief's palace
Date: 20.12.2006

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	22.3	24.3	6.13	11	-	-
B	-	-	-	-	-	-
				$\bar{x}$ 11	-	-

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	11 00
E.coli (col/100 ml)	-
of which 0157 (col/ 100 ml)	-

Date: 20.12.2006

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	28.8	25.1	5.82	3	-	-
B	-	-	-	-	-	-
				$\bar{x}$ 3	-	-

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	300
E.coli (col/100 ml)	-
of which 0157 (col/ 100 ml)	-

Sample site: Luankuni
Date: 15.12.2006

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	25	22.6	6.87	337	17	5
B				297	17	2
				$\bar{x}$ 317	17	3.5

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	31 700
E.coli (col/100 ml)	1700
of which 0157 (col/ 100 ml)	350

Date: 06.02.2007

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	30	22.8	6.80	194	2	-
B				166	2	-
				$\bar{x}$ 180	2	-

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	18 000
E.coli (col/100 ml)	200
of which 0157 (col/ 100 ml)	-

Sample site: Luampesa
Date: 15.12.2006

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	27	21.5	6.82	159	14	5
B				126	6	3
				$\bar{x}$ 142.5	10	4

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	14 250
E.coli (col/100 ml)	1000
of which 0157 (col/ 100 ml)	400

Date: 10.02.2007

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	30.8	23.5	6.67	169	6	4
B				185	8	1
				$\bar{x}$ 177	7	2.5

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	17 700
E.coli (col/100 ml)	700
of which 0157 (col/ 100 ml)	250

Sample site: Kwesha
Date: 22.12.2006

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	30.2	22.2	6.32	142	-	-
B				146	7	-
				$\bar{x}$ 144	3.5	-

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	14400
E.coli (col/100 ml)	350
of which 0157 (col/ 100 ml)	-

Date: 06.02.2007

Sample	t/ °C Air	t/ °C Sample	pH	Total coliforms col/ ml	E.coli col/ml	of which 0157 col/ ml
A	31.3	23.5	6.37	201	1	-
B				172	2	1
				$\bar{x}$ 186,5	1.5	0,5

Results from the final count (after 48 hours incubation) are averaged and the mean is multiplied by 100 to achieve general reporting units for bacteria (col/100ml) (WHO).

Total coliforms (col/100 ml)	18 650
E.coli (col/100 ml)	150
of which 0157 (col/ 100 ml)	50