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Tap Design Review in Emergency Water Supply

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ABSTRACT

A standpost in emergency situation is often made up with six different self-closing unity taps. The aim of this study was to determine which taps are most suitable in emergency situations, in order to make recommendations of use to field workers and to help constructors to review their design.

To achieve these results, data via internet contacts and interviews have been collected. Afterwards, these results have been completed with a laboratory phase of comparison between taps. They have principally to fulfil the following characteristics: robustness with an affordable cost, a good discharge at very low pressure, some proprieties to avoid loss (good quality of the jet, no leakage and difficulties to tie up the tap) and no contamination hazards.

Finally, this research revealed that the gravity flow taps as the “Talbot” and the “Scat” should not be preferred because of their important contamination hazards. The recommended one would be for the moment the one used by “Médecins Sans Frontières” (France and Belgium), produced by Aubia, a lever push tap, yet easy to tie up.

Last, existing circular handle push taps are not suitable yet, but, with an improved design, they would be preferred, given that they are more difficult to tie up. Recommendations about adapted push taps construction for emergency use have been suggested to constructors and may be available soon.

ACKNOWLEDGEMENTS

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Secondly, I would like to thank Dr Paul Trawick for his help on the preliminary correspondence draft and Nigel Janes for precious help to prepare and to make the best experimental protocol possible during the laboratory phase. I would like also to thank particularly Dr. Dave Aldred for his help on the preparation of the contamination risk study and for his work on the microbiological survey (especially for his work on the evening of the 29th of July).

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LIST OF SYMBOLS

ERU: Emergency Response team, IFRC

ICRC: “International Committee of the Red Cross”

IFRC: “International Federation of Red Cross and Red Crescent Societies”

IRC: “International Rescue Committee”

MSF B: “Médecins Sans Frontières Belgium”

MSF F: “Médecins Sans Frontières France”

MSF H: “Médecins Sans Frontières Holland”

UNHCR: “United Nation High Commissioner for Refugees”

WHO: World Health Organization

1. INTRODUCTION

1.1 Problematic

According to the WHO/UNICEF Joint Monitoring Programme, more than one out of four people in the developing world lacks access to water. This is the reason why more than 3,900 children die per day under the age of five in rural villages and urban slums (WHO/UNICEF 2004). In order to tackle this problem the United Nation in its ‘Millennium Development Goals’ has aimed to halve the proportion of people worldwide without access to freshwater by 2015. Thus, in order to reach this goal, a global investment in all forms of water-related infrastructure is needed (UN 2002). One part of this infrastructure is the water system. It includes tank, pipes, pumps, valves and standpost in order to ensure the water distribution (ITDG 2002). Those materials may be chosen locally although the quality is not as good as imported materials (Davis & Lambert 2002).

In emergency settlements, health risks arise through a combination of stress and lack of sanitation (Adams 1999). Then, the water that is used often needs to be chlorinated, especially when it comes from surface or shallow ground water, because of its poor quality. Therefore, a basic water distribution point as the following one has to be ensured:

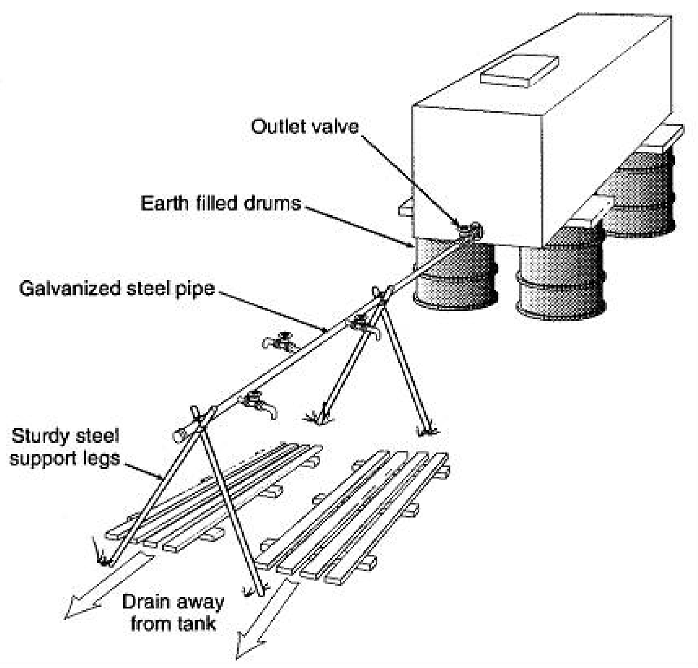

Figure 1.1: Temporary water distribution point (Davis & Lambert 2002)

In this example as in others, an elevated tank is used to obtain a reliable feeding of water to the distribution system (ITDG 2002). The pipe used between the tank and the standpost is generally from two to five inches wide. A one inch diameter pipe is never longer than ten meters in order to limit the water friction on the pipe (ITDG 2002). In addition the standpost distribution system is often composed of 1 inch diameter rigid pipes and six taps; as the OXFAM or MSF tapstand kit.

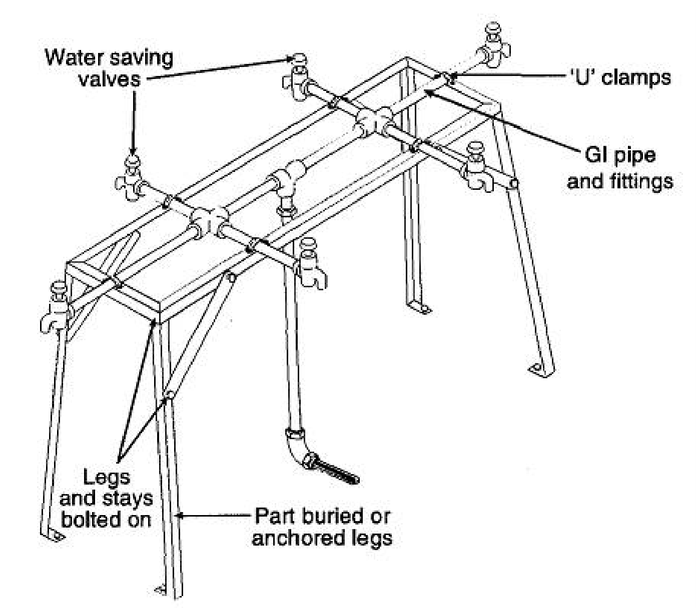

Figure 1.2: Emergency standpost kit with 6 taps (Davis & Lambert 2002).

The taps of a water system must meet a number of specifications, especially in emergency relief situations. Some of them are firstly, the robustness and durability of the tap, because of the constant and heavy usage they face; secondly, the discharge from the faucet, as restricted discharge means extended time periods to fill buckets, which can in turn lead to friction amongst consumers (Jordan 1980); and finally, limiting the water-hand contact in order to prevent contamination problems (Howard 2005). Thus, determining which tap is the most appropriate in an emergency situation and which criteria it must fulfil are of paramount importance.

Since 1984 OXFAM, in common with other emergency relief organisations has mainly relied on the 'Talbot' self-closing gravity tap, specially created for emergency relief. The reason why this faucet has proved to be the most common choice is because it best fulfils certain criteria, especially robustness and durability. However, no studies, exploring whether it is the most appropriate choice, have been published.

1.2 Aim and objectives.

The aim of this study is to determine which current tap designs are most suitable for use in emergency situations.

The objectives of these studies have been (a) to determine the desirable performance criteria for taps in emergency water supply; (b) to obtain samples of taps; (c) to evaluate existing taps against the desirable performance criteria; (d) to investigate the degree of contamination from hand-water contact by using the tap (e) to involve organisation in the conception of new tap designs accordingly.

2. LITERATURE REVIEW

2.1 Water supply improvement stages

Water distribution is often developed in stages (IRC 1979). It means that the more a community's living standard improves, the better the water distribution will be. Actually, women in rural Africa often walk eight kilometres or more every day to fetch water (WaterAid 2000). And yet, according to the WHO/IRC (1979), this walking distance should not exceed 500 m; 200 m would be a more acceptable distance wherever possible. So, the first improvement regarding water supply would be to reduce the spacing of access points to water, and thus the distance to carry water. A clearly defined group of households may also share an outside tap. Having a household connection is the purpose of most communities: with in-house plumping or yard connection (IRC 1979).

In emergency situations it is obviously not possible to establish a private connection. Instead, the water distribution system must be simple in order to be installed as quickly as possible (UNHCR 2000, ITDG 2002). It is however necessary to ensure that the coverage of the water system is great enough to benefit the whole camp (UNHCR 2000). The Sphere guideline (2000) recommends to reduce the walking distance to water to 500 m.

2.2 Main components of a tapstand

In long-term development, the main components of the standpost are the supporting post, the platform or apron, the service pipe and the taps (IRC 2002, ITDG 1991). A main valve is required to isolate the unit and a further control valve can be incorporated if the flows need to be restricted. A meter may be used for charging consumption and for monitoring, but it is often prone to damage (ITDG 1991, Jordan Jnr 1980). The following figure illustrates these components.

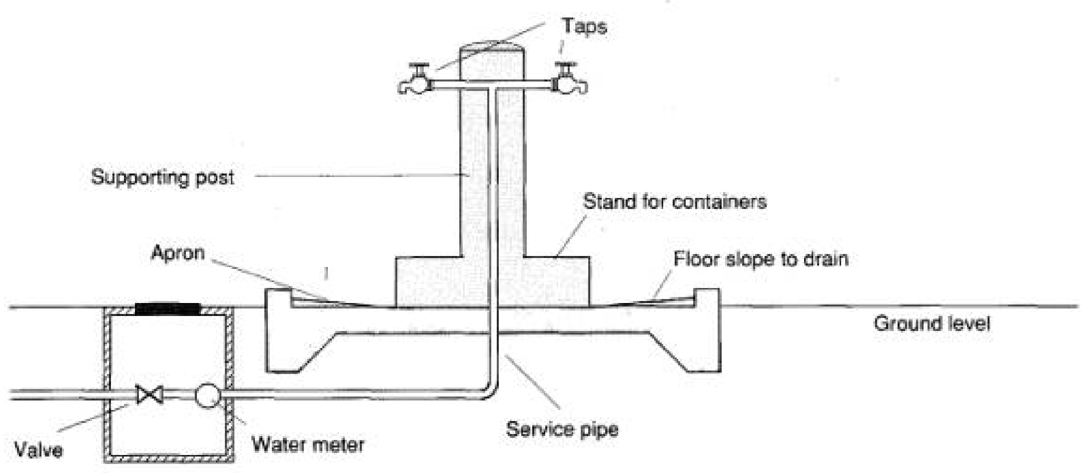

Figure 2.1: main components of a standpost (Source: ITDG 1991)

Furthermore, in emergency situations as in long-term development an important part of the standpost is spillage. Actually, waterpoints can become very unsanitary places (ITDG 2002). Thus soakaways, where soils are sufficiently permeable or vegetation plots in impermeable layers, may be used. In some cases it is also possible to drain water loss for animal's drinking water (David & Lambert 2002).

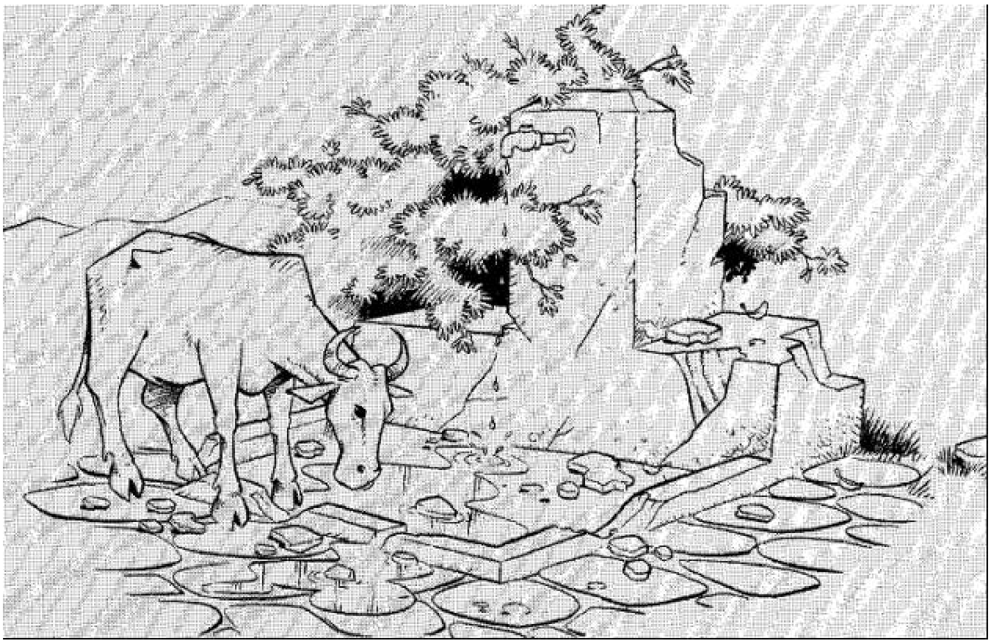

Figure 2.2: Unsanitary tapstand (Source: Leermakers 2000).

2.3 Caretaking of tapstands

In emergency, as in development conditions, users have to be encouraged to manage their own taps, such as initiating a system of reporting faults (Davis & Lambert 2002). However, it is still recommended by the UNHCR (2000) to control the access to water to refugees. A solution is to have a voluntary caretaker for each standpost. This individual needs to be trained to be able to use the different tools, to change the tap washers, to do small masonry work or to clean tanks and tapstands (Leermakers 2000). Women usually show a keen interest in this training (Leermakers 2000). These people may need to be motivated by receiving small incentives (Davis & Lambert 2002)

2.4 Taps used in emergency situation

In extreme emergency situations it is vital that a minimum of 3 litres of water per person is provided. This may be ensured by valve distribution points with tap caretakers, when the site is crowded (UNHCR 2000), in order to supply water as quick as possible

However, emergency organisations often target to supply 15 litres of water per person, per day (Sphere 2000). Then, multiple tap standpipes of between 5 and 10 individual taps is a much more suitable solution (UNHCR 2000, ITDG 2002). The following taps are the ones that may be used in emergency situation.

2.4.1 Non self-closing taps

Firstly, the “common bib tap” (“screw tap” / “ordinary household tap”) may be chosen because it is the most available and simple to maintain: the valve washer has to be replaced regularly to prevent leakage or sometimes the whole tap has to be changed. Secondly, when possible, local taps with ball valve are often preferred to screw taps (Davis & Lambert 2002, Conti 2005) as it is more robust and gives a lower head loss than other taps (IRC 1979).

The problem with these non-self-closing taps is the maintenance aspect and that they are often left open (Davis & Lambert 2002).

2.4.2 Immediate self-closing tap

There are two kinds of self-closing taps: spring loaded or push taps and gravity-operated tap. The first one is closed by spring action and the second one by gravity immediately after the user's hand is removed (ITDG 1979). With these taps, the user has to apply some force with the hand in order to keep the water flowing. This is a good option in emergency situation or any situation where waste of water has to be avoided (Davis & Lambert 2002). Moreover it proved to be successful in camp maintenance costs (UNHCR 1992). Self-closing taps may however be blocked by means of a rope, wire or stone attached to the handle (ITDG 1979).

2.4.3 Delayed-closing taps

This tap has a more complex mechanism because the tap stays open for a fixed period of time after the handle is operated (ITDG 1979). This may be the most effective at reducing waste at unsupervised standposts (ITDG 1979). However, they need maintenance by a skilled staff (ITDG 1979).

3. METHODOLOGY

This research project has been suggested by Andrew Bastable, Oxfam's Senior Public Health Engineer. Because of the lack of information about taps and their design, interviews and laboratory testing had to be employed to garner reliable data.

3.1. Personal communication methodology

Between the 18th of May and the 6th of June (Appendix 2), interviews were conducted at Cranfield University with staff members and students that have already worked in the field of emergency relief. Further contact with other field workers was also established through these interviews (Appendix 1.3). Subsequently on the 6th of June a preliminary correspondence was drafted in collaboration with Paul Trawick (Appendix 1.1), and sent to a number of organisations (Appendix 1.2 & 1.3).

3.1.1 Websites and e-mail investigations

Between the 6th and the 22nd of June, an internet inquiry was carried out in order to find organisations suitable for involvement in the project (Appendix 1.2). 47 organisations were found and emailed. On the 22nd of June Daudi Bikaba, OXFAM engineer, provided some personal contact details for a number of organisation workers (Appendix 1.3). The following step was to ask the organisation to send out questionnaires onto the field. Three were written and mailed: one for MSF France logisticians (Appendix 3.1), one for OXFAM engineers (Appendix 3.2) and a long-term development question for “WaterAid”, UNICEF, and CARE (Appendix 3.3).

3.1.2 Interviews (Appendix 2)

Two kinds of interviews took place: face-to-face interviews and telephone interviews. Each interview varied depending on the interviewee (i.e. time they could afford and personality) and on the stage of the research project. As during the email exchanges, the principal points discussed were: the different criteria which must be considered when choosing a tap, the name of taps that are being used in the field, a critical appraisal of the taps that are being used and why the others were rejected, and the longevity of the taps.

Afterwards, some questions relating to specific taps were asked. First, the users of gravity flow taps were interviewed about the degree of leakage. Then, long-term development workers were questioned about the community preference for a robust or a non-robust tap.

3.2. Laboratory phase methodology

On the 10th of June, as many European tap companies as possible were contacted (Appendix 5) via links pages on the internet and then re-contacted on the 23rd of June, requesting faucets for testing. In most cases there was already a contact with the producer through discussions with organisations which meant the faucets were obtained quicker and more easily. The laboratory phase took place from the 25th to the 29th of July. Four other taps from the Presto and Delabie companies arrived after this period and so were not tested (Appendix 4.10-4.12)

3.2.1 Laboratory work organisation

The issues that had to be evaluated during the laboratory phases were: the discharge, the force needed to turn on the tap, the ease of repair, the loss of water and the contamination of collected water. In order to test all these taps and to obtain the most reliable data, an emergency tapstand from OXFAM was used (Appendix 7.2), Taps were set at 80 cm from the ground and a 10 m length and 1" diameter pipe (Appendix7.4) was used.

3.2.2 Discharge and force evaluation.

Discharge tests have already been made by MSF in Bordeaux (France) in 1995 (Appendix 6). However, these results were incomplete: important pressure as the ones inferior to 2 m were not taken into consideration and only four taps were studied: the "Talbot" (Appendix 4.3), the "Aubia" (Appendix 4.5), the "Hi Flo" (Appendix 4.7), and the "Presto" (Appendix 4.12).

Discharge (Appendix 8) and force (Appendix 9.1) needed to turn on the tap were measured at the following different elevations between taps and the tank: 0.37 m, 1.08 m, 1.88 m, 4.35 m, and 7.63 m. The main tap pressure (49 m) was also tested.

In order to measure the discharge of the different taps, a 10 litre bucket was used. The time taken to fill a proportion of the bucket was recorded and the volume of water measured using measuring cylinders (Appendix 7.6). The discharge was given in litres per minutes, which is the most representative unit for many Emergency workers (Fesselet 2005):

Discharge (l / minutes) = volume of water (l) / time to fill the volume found (s) * 60

The force needed was determined by using a spring balance (Appendix 7.7). In order to represent the results in Newton the following equation can be formulated:

$$F\ (N) = m\ (kg) * g\ (9.81\ N.\ kg^{-1})$$

3.2.3 "Ease of dismantling" evaluation.

In studying the ease with which the taps could be dismantled and reassembled, it was not possible to employ qualitative testing techniques, such as timing of dismantling/reassembling. Instead, photos adequately illustrate the respective ease and difficulty with which the different taps were stripped and put back together (Appendix 7.13 - 7.17). However time limitations did not allow a thorough testing in this area, but it was not necessary.

3.2.4 "Minimizing water lost" evaluation.

The water distribution system should minimize waste (UNHCR 2000). Thus, leakages were observed during this experiment (Appendix 7.5), especially at low pressure: according to the results of the interviews, gravity flow taps such as the "Talbot" shown out to be often leaky under the pressure of 4 m.

Secondly, the water loss due to a dispersed jet during the bucket filling (Figure 3.1) was taken into consideration by measuring the diameter of the jet at floor level (the height of the tapstand was 80 cm).

Finally, both organisations that use and do not use self-closing taps cite the ease with which they can be tied by the consumer as a contentious issue. It is the reason why organisations that choose not to use self-closing taps do so (Conti 2005, Kentish 2005). However, organisations which use self-closing taps criticize them also for this flaw. Thus, the time to close up a self-closing tap (Appendix 7.13-7.18) with an iron wire was measured.

Figure 3.1: wastage with a bad jet
Source: Shrestha UNHCR

3.3 Contamination risk evaluation methodology

3.3.1 Introduction

It has been proved that hands play a very important role in the transmission of diarrhoeal disease. Water, safe at the source, is contaminated by hands which are covered with faecal matter and so brings diarrhoea into the home. (Cibulkis & al. 1995, IRC 2002, Trevett & all 2005).

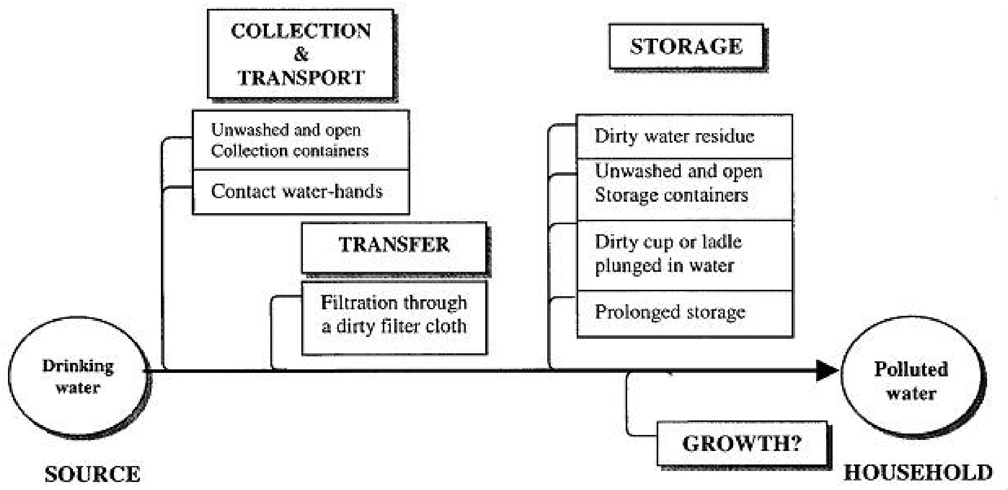

Figure 3.2: drinking water faecal pollution factors (Empereur-Bissonet 1992)

This figure reveals that contamination is due to different combined causes. Yet, the actual effect of each parameter is difficult to ascertain and they need to be tested separately (Janin 2000). Tap contamination is one of them (Appendix 7.24).

Even if the WHO guidelines for faecal contamination are 0 Faecal Coliforms / 100ml, the Sphere guideline considers that 10 faecal coliforms per 100 ml at the point of delivery are acceptable. These guideline figures are related to the water quality at the source. However, there are no guidelines about the household situation and the contamination hazard is still high (Trevett & al. 2005).

3.3.2 Shape evaluation and contamination issue.

This part of the research was a fluid process running throughout the course of the practical work and had no straight methodology. The whole tap was observed: the kinds of leakage and contaminated position that may be taken during water filling were assumed.

3.3.3 Gravity flow taps contamination risk evaluation.

3.3.3.1 Test preparation

Water preparation: the first important point was the choice of the water quality; 150 litres of borehole water were used, as chlorinated mains water would have changed the bacteria concentration.

Taps preparation: The second important point was to collect only contaminated water. To this end, a rubber stopper was used to bung the end of the taps (Appendix 7.29). It created a leakage from the upper part of the tap and caused water to flow over the contaminated hand. In this way only contaminated water was gathered. The tank was set at 5.80 m, and so the head of the water at the tap inlet was 5m. Actually, the leakage origin is situated at the tap inlet.

"Excreta substitute" preparation (Appendix 7.27): The most important aspect of this phase was to create a substitute for excreta that was as close as possible to the real thing, in terms of consistency and bacterial concentration. To simulate the consistency of excrement a primarily cellulose substance, with very fine texture, relatively homogenous, spongy and non-toxic was chosen (Aldred 2005). A mixture of 5 grams of "ready oats" and 50 ml of water was suitable.

With regard to the bacterial concentration, there were more than 10^9 Faecal Coliform per gram in excreta (Freney 2000). This inoculum was created by using 0.1 ml of laboratory culture of non-pathogenic Escherichia Coli (*E. coli*) grown in a flask with 50 ml of Oxoid Nutrient Broth. It was then shaken at 25 degrees overnight. The cells were finally put in a Saline solution of 0.7 % of sodium in order to avoid their destruction with the osmosis effect when in contact with the "ready oats".

Finally, these two substances were mixed together (Appendix 7.28). Meanwhile, 0.1 ml of inoculi was mixed with 0.2 g of ready oats in order to be used for each different test. The concentration of the final "excreta substitute" was 2.1. 10^9 *E. coli* / mg.

3.3.3.2 Experiment.

Because there was no significant difference between using gloves or not using gloves in the contamination experiment (Janin 2000), this part of the experiment was done by smearing 0,2 g of non pathogenic substances on gloves. In order to simulate the real-life situation a 3-minute interval period was observed, in which attempts were made to wipe off the “excreta substitute”. It proved significance as 99% of the bacteria died within 2 minutes of application (Snyder).

Taps Tested: Four taps were tested. The first tap was a new gravity flow “Even Product”, to which some modifications were made. The layer of grease that forms a seal between the body and the plastic component was removed to simulate natural wear and tear. When it was new, there was no leakage at all from the upper part of the tap. However as soon as the grease was removed there was some leakage. The second tap was a new “Talbot” which was not modified and some millilitres leaked when turned on. The third tap was a new “SCAT” and the fourth was an older Scat which came from J.F Fesselet (2005), WATSAN specialist in MSF Holland.

Position Tested: Two different positions were studied: the “gun position” (Appendix 7.26) and the “grasp position” (Appendix 7.27). Indeed, when the tap is being used it can assume those two positions.

Finally, seven samples of contaminated water were analysed; the old “SCAT” was studied only using the “gun position”, because the significant leakage of this tap (510 ml per 10 litres) provided substantial evidence that this tap contaminates the collected water. The quantity of water for each sample was measured, as was the concentration of coliforms.

3.4 Organisation of the laboratory phase.

Table 3.1 : Laboratory work organisation (Appendix 6-10)

Days	Operations	Persons involved
25/07/04	• Installation of the taps (Appendix 7.2) and flexible pipe connection with a 1" garden hose • Main tap pressure test • General observation 1*	**Mr Nigel Janes**
26/07/04	• General observation 2* • Microbiological protocol preparation 1*** • Towel testing (Appendix 7.1) in the "Norman Hudson Building". Garden hose and bad experimental design were used to do a first study. No flow at all or very low flow	**Dr Dave Aldred,** **Mr Nigel Janes**
27/07/04	• Change of flexible pipe (Appendix 7.4) and of general design to avoid friction lost: Change of valve and of tank position • Force and discharge measurement (Appendix 7.5-7.6) for the following tank elevations: 8.43m, 5.15 m, 2.70 m, 1.88 m	**Mr Nigel Janes**
28/07/04	• General observation 3* • Force and discharge for 117 cm water head. • Ease of dismantling evaluation 1** • Microbiological protocol preparation 2***	**Mr Servera-Martinez**
29/07/04	• General observation 4* • Tie up study with iron line (7.13-7.18) • Microbiological protocol preparation 3*** • Ease of dismantling evaluation 2** • Microbiological survey (Appendix 7.27-7.29)	**Dr Dave Aldred,** **Mr Nigel Janes,**

**The general observation included general design observation of the different shape of the taps (Appendix 4), modification suggestion tests (Appendix 7.19-7.20), and contaminant leakage observation Appendix 7.21-7.22)*

***The ease of dismantling evaluation was tested by manual dismantling (Appendix 7.8 - 7.12)*

****The microbiological protocol preparation included an important collaboration with Dr Dave Aldred.*

4. RESULTS AND DISCUSSION

4.1 Global results of the research

4.1.1 Personal communication methodology weak points

From the 47 mails that were sent during the website investigation (Appendix 1.2), only one response was received: from “WaterAid”. The questionnaires (Appendix 3) sent onto the field also received only a low feedback. The reason for this is due to the vacation period, which is the most difficult time to manage for these organisations (Mulloni 2005). In fact research emails are often lost, as they are not a priority (Isard 2005). The lack of replies may also be due in part to the fact that it is necessary to make repeated requests, which was not done. In addition to this, some questions may have been awkward to field workers.

However, from the contacts that were supplied by Gilles Isard of MSF France and Daudi Bikaba (Appendix 1.3), ten organisations replied, but often only between two and four weeks after the initial email was sent.

4.1.2 Desirable performance criteria for taps in emergency water supply

The following table summarises the different essential criteria, according to the following organisations: OXFAM, ICRC, IFRC, IRC, MSF France and MSF Holland.

Table 4.1: Principal criteria for emergency organisation

Criteria to study	Number of organisation that mentioned this criteria /6	Reasons
Cost	6	-
Self closing	5	Minimize water lost
Discharge	5	Minimize waiting
Force exerted to turn tap on	2	Children are often users
jet quality	4	Minimize water lost
Ease to play	1	Minimize water lost
Leakage at low pressure	4	Minimize water lost
tie up difficulty	2	Minimize water lost
Ease of dismantling	2	Minimize cost
Durability during use	4	Minimize cost
Robustness (transport and use)	4	Minimize cost
Contamination issue	1	Minimize contamination

4.1.3 Results of the different criteria studied

The following table is a summary of the results from the laboratory phases (Appendix 7-10) and the different personal communication. Details of the advantages and disadvantages are detailed on the discussion section which follows.

Table 4.2: Summary of personal communications and laboratory phase

Items	**“Talbot”**	**Gravity flow “Even Product"**	**Push tap “Even Product”**	**“Scat”**	**“Aubia”**	**“Hi Flo”**	**“880 Prestex”**	**European delayed push taps**	**Screw taps**
Cost (€) :	11.5	9.40	9.40	11.90	7.50	-	43.30	10 - 20	2 - 5
Cost with transport (€)	14.6	12.2	11.3	13.3	9.1	-	46.4	12-22	4-7
Self closing	4	4	4	4	4	4	4	4	0
Discharge	1	4	1	2	4	4	2	0	2
Force exerted to turn tap on for less than 10 m	4	2	4	3	2	2	2	2	2
Force exerted to turn tap on at 50 m	1	0	1	2	1	1	2	2	2
Jet quality	1	2	2	4	2	0	2	4	0
Ease to play	0	0	0	0	0	0	0	0	0
Leakage at low pressure	0	0	4	4	4	4	4	4	4
Ease to tie up	0	0	2	0	1	2	2	2	-
Ease of dismantling	3	2	0	2	0	0	1	1	2
Robustness	3	0	0	1	2	1	4	4	0
Contamination issue	0	1	1	0	3	1	3	1	1

Legend:

4	Very appropriate
3	appropriate
2	Acceptable
1	Acceptable but presents risk
0	not appropriate

N.B: *The cost of the transport is based on 4.5 € per kilogram (Dal 2005). Other scores were determined according to the following criteria:*

Discharge (Appendix 6 & 8):

Minimum tap inlet head (m) to reach the 7.5l/min of minimum discharge (Sphere guideline 2000):
- *(4): H < 0.25 m*
- *(3): 0.25 m < H < 0.5 m*
- *(2): 0.5 m < H < 1.0 m*
- *(1): 1.0 m < H < 5 m*
- *(0): H > 5 m*

Force (Appendix 9.1):

- *(4): F > 10 N*
- *(3): 10 N < F < 20 N*
- *(2): 20 N < F < 100 N*
- *(1): 100 N < F < 200 N*
- *(0): F < 15 N*

N.B: The results from using a high head of water was taken into consideration as these extreme conditions were encountered in some refugee areas such as in Rwanda (Isard 2005).

Jet quality (Appendix 9.2):

Jet diameter, 80 cm below the tap:

- *(4): D > 2 cm*
- *(3): 2 cm < D < 5 cm*
- *(2): 5 cm < D < 10 cm*
- *(1): 10 cm < D < 15 cm*
- *(0):D < 15 cm*

Ease to play.

- *(0): Every taps were found out not to be relevant.*

Tie up difficulty with an iron string (Appendix 9.3)

- *(4): It is impossible to tie.*
- *(3): It takes more than 5 minutes to be tied, and they are very difficult to secure firmly*
- *(2): It takes more than 30 seconds to be tied, and they are very difficult to secure firmly*
- *(1): It takes less than 30seconds with an iron string, but it is not secured firmly*
- *(0): It takes less than 30 seconds to secure firmly with an iron string*

Leakage at low pressure

- *(4): There is no leakage at low pressure.*
- *(0): The tap often leak at low pressure (10% and more).*

Ease of dismantling.

- *(3): Easy to dismantle*
- *(2) : Easy to dismantle and reassemble but may break*
- *(1): Complex spare parts and technical work.*
- *(0): Taps that cannot be dismantled.*

Robustness

- *(4): Robust and durable (transport, use & storage), no water hammer risk in high pressure.*
- *(3): Robust and durable, but may break in high pressure (20 m), with the water hammer*
- *(2): Robust and durable, but handle may break during transport*
- *(1): Fragile taps*
- *(0): Very Fragile taps: broken during the practical experiment.*

Contamination risks (Appendix 6)

- *(3): No risks observed*
- *(1): contamination risk*
- *(0): major contamination risk*

N.B: the contamination risk results in Appendix 6 proved the importance of the contamination issue with gravity flow taps, which is, in non-treated water a major source of contamination (Hakizamungu 2005).

4.2 Discussion of the different tap uses

4.2.1 The different faucet used in emergency situation and their advantages.

4.2.1.1 Gravity flow taps.

Since 1982, OXFAM has been using the “Talbot” (Howard 2005). This tap (Appendix 4.3) is a gravity flow self-closing valve (Tyco Waterworks). All the emergency organisations have used or are currently using this valve. This tap is very robust, even during transportation (Lemetayer 2005) and according to the personal contacts this tap has the greatest longevity (when washers are available) and has both a good discharge and no leakage when it is used with 4- 8 m of water head.

Another gravity self-closing valve is now used by the majority of the organisations: the “SCAT” self-closing valve. This tap (Appendix 4.1), has been specifically developed for low-pressure use whilst retaining easy operation in high-pressure situations. (SCAT). Furthermore, this tap also has a very good jet quality (Appendix 9.2) and the texture of the tap, in PVC, is user-friendly (Broadhust 2005).

A third gravity self-closing valve from Even Product is situated in Appendix 4.2. 20.000 items of this tap were sold since January 2005 (Rowland 2005) by emergency organisations, thanks to its low cost and reliability (Rowland 2005).

4.2.1.2 Push taps with lever

These taps are normally used in order to supply oil. Thus, the tap was designed to give minimum head loss. The Spanish Red Cross is currently using this tap, in Appendix 4.4, produced by Robert Manufacturing. In 1995, Aubia developed a new tap especially for MSF Belgium and MSF France (Isard 2005). This new design, situated in Appendix 4.5, incorporates an extended nozzle in order to improve the quality of the jet and to avoid contamination problems (Isard 2005). Furthermore, they have replaced the straight lever with a curved one to avoid breakage during transport and manipulation (Dal 2005).

4.2.1.4 Push taps

Normal push taps such as the “hi-flo” tap from “Plastec Norway”, especially created for emergency relief, (Appendix 4.7) are not currently used. However, “Even Product” obtained a new kind of tap especially for this laboratory work, situated in Appendix 4.6, and requested it to be tested in order to know if it might be appropriate.

Otherwise, delayed closing push taps have exceptionally been used. The 880 Prestex self-closing tap in Appendix 4.8, is used by the ICRC in situations where a very strong tap is needed, for example in prisons. Actually, it has a good discharge (Appendix 8), its overall design helps to avoid contamination (Appendix 10) and makes tying up difficult (Appendix 9.3). Furthermore, the “Delabie Tempostop” taps situated in Appendix 4.10 & 4.11 were used in refugee camps in Europe during the Balkan crisis.

4.2.1.5 Local taps

In some emergency situations, local taps are used, such as the ball valve, which is generally chosen by organisations when no other solution is available (Lemetayer 2005); but it is ICRC’s first choice (Conti 2005).

4.2.2 The weak points of the principally used taps

In this part, the different weak points of taps were found not only with the test results, but also thanks to internal and external critics: knowing why another tap is not used was essential for the research

4.2.2.1 The weak points of the gravity flow taps

Gravity flow taps have two major problems: they are easy to tie-up (Appendix 9.3), they have fragile washers (Thuvarakan 2005) and, in higher pressure than 4 m, they may contaminate bucket water (Appendix 10.2) due to leakage from the upper part.

With reference to the Talbot and to the Even Product, these taps have a limited range of efficacy: between 4 and 8 m of water head. In fact, they often leak in lower pressure, especially the Even Product one: 22 l / hours during the practical work. In important pressure, particularly up to 20 m, the tap is very difficult to open and it breaks with the water hammer. (Isard 2005).

Moreover, the “Talbot” has a bad quality of jet (Appendix 9.2) and the “Even Product” is fragile when dismantled.

Finally, even if the "SCAT" has not this limited range of efficacy, it breaks easily. Furthermore, the laboratory work revealed that this valve has a very important problem of contamination risk (Appendix 7.9)

4.2.2.2 The weak point of the lever push tap: the "Aubia".

The principal disadvantage of the Aubia is its longevity: one tap per MSF standpost (six taps per standpost) has to be changed per 2-6 month when used in refugee camp (Mulloni 2005, Lemetayer 2005, Coyl 2005). Half of the breakages are due to the spring. Furthermore, the lever may be broken during transports (Lemetayer 2005), it is easy to tie up (Appendix 8.4) and it needs significant force to open it (Appendix 8.2).

4.2.2.3 Weak points of the "European type taps".

European delayed taps has the disadvantage to have very low discharge at low pressure (Appendix 8), which makes them irrelevant. The only one that is adaptable is the 880 Prestex (Appendix 4.8), but this tap is much more expensive than emergency taps (47 € with transport) and its design should be changed in order to have a better quality of jet (Appendix 7.20 & 9.2).

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

5.1.1 Conclusion about personal communication with emergency organisations

The interviews revealed that the principal criteria that organisations are awaiting are: robustness, durability, the capacity to avoid leakage, a good discharge and an affordable cost. These interviews revealed also that there are no taps that perfectly satisfies logisticians and engineers. Finally, these interviews revealed that questions to gather precise data (like durability) are often awkward to field workers.

5.1.2 Conclusion about the taps used in emergency situation

Finally, After all, the tap which is the most used by emergency organisations is the “Talbot tap”. It actually revealed to be the most robust and durable one, but has a serious problem of leakage: constant leakage (Appendix 7.5) in lower pressure than 4 m of pressure and contaminant leakage (Appendix 10) in higher pressure than 4 m. The “SCAT” (Appendix 4.1) is another gravity flow tap that has a better discharge and do not leak in low pressure. However this valve is not appropriate for higher pressure that 4 m because it has important contaminant leakage (Appendix 7.24 & 10)

The “Aubia” tap (Appendix 4.5) was shown to be little expensive (7.5€) and of good quality, although it is less durable than the Talbot. The other taps does not respond to the principal criteria requested by organisations or are too expensive as the Prestex (43€).

5.1.3 Conclusion about the design of the taps used in emergency situation.

According to this study, (Table 4.2 p 17), there is no design completely suitable. The most suitable tap design in emergency situation would be the push handle design (Appendix 4.6-4.12), but only if a minimum discharge of 7.5 l/min would be ensured. Actually, gravity flow tap designs (Appendix 4.1-4.3) would allow contamination problems (Appendix 10) and lever push taps as “Aubia” taps (Appendix 4.4-4.5) have lever apart from the tap body (Appendix 7.11), which may break during transport and during use. Furthermore, these two designs are very easy to tie up (Appendix 8.4) which may be an important problem of wastage. Finally, the “Aubia” tap seems to be attractive for children (coyle 2005), who tend to play with it. A more detailed study about this problem might be important.

5.2. Recommendation

5.2.1 Recommendation about personal communication with emergency organisation

The most important advice to give, regarding personal communication with emergency organisations, would be that researchers should recontact organisations that do not answer back. This should be done every-two weeks, but no more than twice because more frequent request may annoy organisations. Furthermore, questionnaires and internet contacts should avoid to research precise data (like durability or percentage): precise data have to be tested in laboratory.

Finally, in the initial stages of the project, interviews were crucial, however after the first month they became irrelevant and difficult to organise due to numerous reasons, especially the progression speed of the project. Whereas email communication, as relevant as interviews, which is an easy and quick means of gathering and that can be exploited throughout the duration of the project.

5.2.2 Recommended tap for emergency situations

"Prextex" tap (Appendix 4.8): When a very strong tap is needed, as in prisons, the "Prestex" would be the top recommendation faucet.

"Aubia" tap (Appendix 4.5): This tap is the only one that has an affordable cost and that can be used in a very important range of pressure.

"Talbot" (Appendix 4.3) taps can be used but only in higher head than 4 m. Furthermore, because of the importance of the leakage from the upper part of this tap (Appendix 10), the organisation "Tyco waterwork" was suggested to install better quality washers and also to use non-toxic grease on the upper part of the tap (Appendix 7.12). Furthermore, tap caretakers should review every two months that there is no leakage from this part. As a result, both washer and non-toxic grease should be available.

"Scat" (Appendix 4.1) taps can be used but only in lower head than 4 m. Indeed, for this pressure, it revealed to have no leakage at all, a better discharge (Appendix 8) and a very good jet (Appendix 9.2). However this valve is in plastic, thus extremely fragile.

5.2.3. Recommendation of designs modifications.

The organisation "Even Product" has decided to redesign their push taps (Appendix 4.6) accordingly to the findings of this study. furthermore 2 organisations are thinking over designing a new push tap, especially for emergency situations: "Presto" and "Delabie". Actually, these two companies were interested in this research and may produce a new prototype.

Table 5.1: Proposed criteria for self-closing push tap design or modification

Criteria		**Reason**
Cost	10€ (no more than 15€)	-
Range of use	0.3 m – 10 m	Currently used in emergency situation
Closing system	Immediate self closing system.	delayed mechanism would be too complex, and there is no need to avoid water hammer
Discharge	At least 7.5 l/min for 1m of water head	200 users / day / tap
Force exerted to turn tap on	70 N	To increase tie upment difficulty, and ensure good self-closing
Contamination issue	Nozzle of 7 cm length	To avoid water-hand contact and improve jet quality (Appendix 7.19 / 7.20 & 9.2)
Jet quality	Particular attention on the Nozzle inner shape: the 8 cm length should take hydraulic propriety (roughness, adhesive propriety) into consideration	To avoid loss during bucket filling: a 2 cm diameter jet at 80 cm would allow no loss.
Tie up difficulty	Round push tap, and 70 N needed to turn on the tap	-
Ease of dismantling	Very simple	Particles may go on taps, thus would need to be dismantled
Durability during use	Non oxidant material, adapted to non-clean water, and good quality washer	Durability (use and storage)
Robustness	No plastic	Fragile

5.2.5 Recommendation for further research.

The aim of this study was to determine which current tap designs are most suitable for use in emergency situations. Next year, a further research needs to be done, concerning a new tap design. It should also include an overseas observation in a refugee camp. This would allow to study the socio-impact of this component of the water system on population, especially if some taps attract children for playing with them. It would lead, thanks to this thesis, oversee work and precise study upon hydrolic proprieties, to conceive the greatest tap design.

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Appendix 1: first e-mail investigation

Appendix 1.1: Preliminary Email.

Dear .

I am contacting you at the suggestion of Andy Bastable, Oxfam's Senior Public Health Engineer. Oxfam is presently carrying an important study of different water tap designs, specifically regarding their suitability for use in emergency relief situations. In undertaking this study, which has several phases and objectives, our most urgent need at present is the knowledge and experience of individuals like you who have used various kinds of water taps in specific settings.

That being the case, we would be extremely grateful if you would consent to do a short interview with me, on behalf of OXFAM. The interview will focus on the kind of water tap you are now using, the reasons you had for choosing that particular brand and design, how well you think it has performed and met your needs, and how you think it might be improved.

These interviews will be followed somewhat later by a laboratory phase in which we will test the taps' performance and compare this with the previous assessments of users, also experimenting with design modifications, including those suggested by people like yourself.

I hope that you and your organization will be interested in this important project and consent to participate and briefly share your knowledge and experience with myself, Oxfam, and all the people who will ultimately benefit from the study.

Yours sincerely,
Gildas Le-hyaric
Msc Water Management
Cranfield University

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Appendix 1.2: organisations involved in the personal investigation

The following non-governemental organisations were involved thanks to personal knowledge, “Arobanet” (2005) and “Reliefweb” (2004): “Actions against hunger UK”, “Actions contre la fin France”, “Action d'Urgence Internationale”, “Bioforce”, CARE, “Caritas France”, “Catholic Relief Services”, “Center for Disaster Management and Humanitarian Assistance”, “Center for Humanitarian Cooperation”, “Concern”, “Coopi”, “Détachement d'Intervention contre les Catastrophes et de

Formation”, “Direct Relief International DisasterRelief”, “Fondation de France”, “Holy Land Foundation for Relief and Development”, IFRC, ICRC, “Logistic sans frontiers”, “International Aid”, “International Service”, IRC, “Life for Relief and Development”, “Médecins du Monde”, “Mercy Corps International”, “Première Urgence”, “Ordre de malte”, “Secours catholique”, “Secours Islamique Francais”, “Secours Populaire Francais”, “Solidarités”, Wateraid”, “ Water for All”, “Water for people”.

The following Governmental organisations were found thanks to personnal knowledge and the reliefweb (2004): “Armee Francaise”, “International Civil Defence Directory”, “UNHRC”, ”Agence d'Aide à la Coopération Technique et au Développement”, “Organisation for Economic Co-operation and Development”. UNICEF, WHO, “Center of Excellence in Disaster Management and Humanitarian Assistance”, “International Relief and Development”.

Appendix 1.3: organisations contacted via personal e.mail:

The following organisations were contacted via personal e.mails, thanks to the first interviews with Gilles Izard, Daudi Okaba, and James Webster: “Action against Hunger”, “CARE”, “Concern”, ICRC, IFRC, IRC, “Kate Heywet Church Water Programme”, “Kigezi Diocese Water Department”, MSF B, MSF H, MSF F, “Tearfund”, UNICEF, “the WEDC”, WHO.

Appendix 2: Review of communications (1)

Name	Organisation	Professional Internet address	Type of personal communication	Date of the principal personal communication
Gilles Izard	MSF F	-	Face to face interview	18/05/05
James Webster	Cranfield University	r.j.webster@cranfield.ac.uk	Face to face interview	25/05/05
Edith Rogenhofer	MSF H	-	Face to face interview	01/06/05
Andrew Trevett	Cranfield University	a.f.trevett@cranfield.ac.uk	Face to face interview	02/06/05
Jean-Marcel Kavaruganda	MSF B	jeanmarcelk@yahoo.fr	Face to face interview	06/06/05
Benoit Dall	MSF F	Benoit.DAL@bordeaux.msf.org	Face to face interview	14/06/05
Jane Coyl	MSF F	Aide.Operateur@bordeaux.msf.org	Face to face interview	14/06/05
Daudi Bikaba	OXFAM	dbikaba@oxfam.org.uk	Face to face interview	22/06/05
John Oward	OXFAM	joward@oxfam.org.uk	Face to face interview	22/06/05
Nega Bazezew	OXFAM	nbazezew@oxfam.org.uk	Brief face to face interview	22/06/05
Shemeles Mekonnen	OXFAM	smekonnen@oxfam.org.uk	Brief face to face interview	22/06/05
Carsten Völz	Care International	voelz@careinternational.org	Brief internet contact	24/06/05
Matthew Freeman	Care International	mfreeman@care.org	Brief internet contact	24/06/05
Dinesh Shresh	UNHCR	SHRESTHD@unhcr.ch	Internet contact	24/06/05
Niall Roche	Concern	niall.roche@concern.net	Brief internet contact	24/06/05
Francois-Pierre Lemetayer	MSF F	francois-pierre.lemetayer@paris.msf.org	Internet contact / Questionnaire answer	28/06/05
Dennis Kentish	Wateraid	DennisKentish@WaterAid.org	Phone interview	30/06/05
Mogus Mehari	Kate Heywet Church Water Programme	khcdp@ethionet.et	Internet contact	04/07/05

Appendix 2: Review of communications (2)

Name	Organisation	Professional Internet address	Type of personal communication	Date of the principal personal communication
Véronique Mulloni	MSF F	Veronique.mulloni@paris.msf.org	Internet contact / Questionnaire answer	05/07/04
Jean-Francois Fesselet	MSF H	jean.francois.fesselet@amsterdam.msf	Face to face interview	05/07/04
Brian Skinner	Lboro	B.H.Skinner@lboro.ac.uk	Face to face interview	05/07/04
Franklin Broadhust	IRC	franklinb@theirc.org	Phone interview	05/07/05
Mark Henderson	UNICEF	mhenderson@unicef.org	Brief internet contact	08/07/05
Jean Vergain	ICRC	jvergain@icrc.org	Brief internet contact	11/07/05
Wolfgang Stockl	IFRC	Wolfgang.Stockl@ifrc.org	Internet contact	13/07/05
R Conti	ICRC	rconti@icrc.org	Phone interview	15/07/05
Medard Hakizamungu	OXFAM	-	Questionnaire Answer	20/07/05
Martin Dalton	Concern	martin.dalton@concern.net	Brief internet contact	29/07/05
sunthararajah Rajmogan	OXFAM	rajmogans@yahoo.com	Questionnaire answer	04/08/07
Enam Hoque	OXFAM	ehoque@Oxfam.org.uk	Questionnaire answer	04/08/07
Thuvarakan	OXFAM	watsaneng@eureka.lk	Questionnaire Answer	04/08/07
Andrew Bastable	OXFAM	abastable@Oxfam.org.uk	Brief face to face interview	08/08/05

Appendix 3: request for questionnaires to be sent to field engineers and logisticians.

Appendix 3.1: To OXFAM engineers:

1.Which taps have you ever used and what do you prefer?
2.How many taps do you replace and repair after how long? (if you can, please, give the place and date)
3.Have you ever reused any taps? Were they still as robust and did they have any problem of leakage?
4.Question that is more specific for the Talbot: The Talbot is the more robust: it can hold 10 years. How do you feel about the ageing of the tap?
a.leakage on the inferior part of the tap,
b.leakage, thus contamination on the top part of the tap
5.If you have other personal experience or remark, please, comment.

Appendix 3.2 : To MSF France logisticians:

1.dans quelle proportion (approximativement) les robinets que vous avez utilisés ont eu des problèmes techniques et autres ?
2.Quels types de problèmes sont rencontrés principalement ?
3.Dans le cas de réutilisation d'une rampe de distribution, ces robinets sont-ils toujours à l'état de fonctionnement, ou doit-on en grande partie les changer ?
4.à combien de temps de fonctionnement estimez-vous ce type de robinet ?
5.Tout vécu et exemples précis seront bons à transmettre.

Appendix 3.3: To water aid, UNICEF and CARE:

Which taps are used by the water committee you are working for?

a. An European common bip tap, because this is robust so allows not too much maintenance,
b. A local common bip tap (Chinese type), because this is less expensive and the local communities are poor. But this is not preferable.
c. A local common bip tap (Chinese type), because the local communities are poor, but this is suitable for the situation: technicians and water committees have to be often involved in order not to loose their dynamism.
d. Local ball valves, as they are more robust, but more expensive
e. Self-closing taps

Please answer with percentage. Example: 1: 20% 3: 80%

Appendix 4: Self-Closing Taps.

Appendix 4.1 - 4.3: Gravity Flow taps

Appendix 4.1: "Scat"

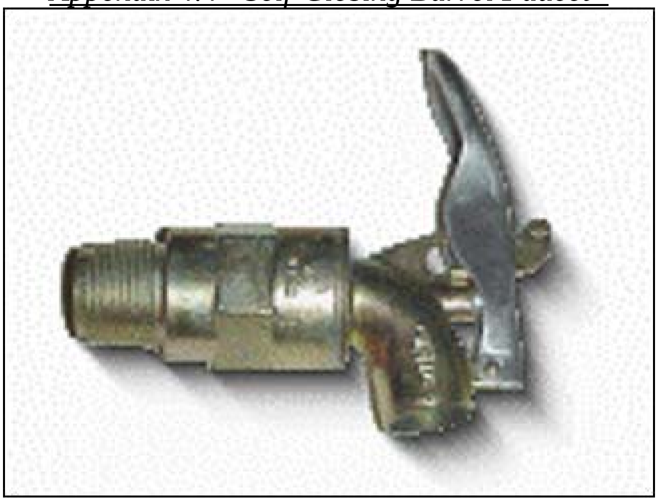
Appendix 4.2: "Even Product" gravity flow tap

Appendix 4.3: "Talbot"

Source: Tyco Waterworks

Appendix 4.4 - 4.5: Push Tap with Lever

Appendix 4.4 "Self-Closing Barrel Faucet"



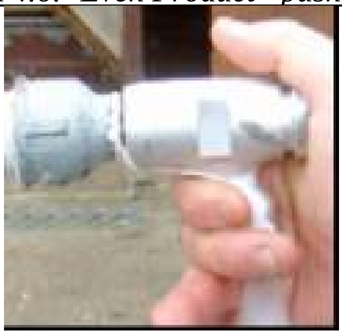
Source: Robert Manufacturing 1997

Appendix 4.5: "Aubia" Self-Closing tap

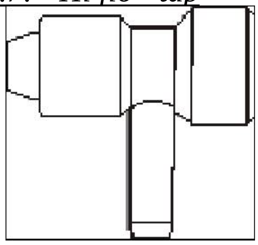
Source: Aubia

Appendix 4.6 - 4.10: Push Taps with Handle.

Appendix 4.6:"Even Product" push tap



Appendix 4.7: "Hi flo" tap



Source: Scanwater 2004

Appendix 4.8 – 4.13: Delayed Closing Taps

Appendix 4.8: "880 Prestex" self-closing tap

Source: Pegler 2004

Appendix 4.9: "883 Pegler" self-closing tap

Source: Pegler 2004

Appendix 4.10: "Delabie Tempostop 746000"

Source: Delabie 2004

Appendix 4.11 "Delabie Tempostop 745100"

Source: Delabie2004

Appendix 4.12: "Presto 507"

Source: Presto 2004

Appendix 5: the tap constructors

Constructors that have been contacted	Product name	Contact mail	First contact date	Previous application of product	Cooperation received
Aubia SA	Aubia Self Closing Taps ¾" M	Dupont Sébastien s.dupont@aubia.be	8th July	MSF B / F / S / S	Have sent 1*2 items
Berkefield	-	berkefeld@veoliawater.com	none	German and Austrian RC (ERU team)	none
Butyl products	SCAT	Jenny Gander jenny@butylproducts.co.uk	23rd June	all	Have sent 1 * 2 items.
Delabie	Tempostop 746000 & Tempostop 745100	Jean-claude Delabie jeanclaude@delabie.fr	10th June	Used in east of Europe in emergency situation	Have sent 2 * 2 items. Arrived after the laboratory phase.
Even Product	gravity 'shut off' tap	Bob Rowland bob@evenproducts.com	23rd June	UNICEF, OXFAM, IRC, Action contre la Faim, Medair, World Vision, One Earth	Have sent 2 * 2 items. Agreed to conceptualise a new item
Presso	No information found about this tap		-	OXFAM, MSF	-
Presto	P 507 & P 712	Fabre Christophe c.fabre@presto.fr	10th June	unknown	Have sent 2 * 2 items. Arrived after the laboratory phase. Agreed to conceptualise a new item.
Pegler Limited	880 self closing Bib Tap & 883 self closing bip tap	Kev Spence KEV.SPENCE@PEGLER.COM	10th June	OXFAM, ICRC	Have sent 2 * 2 items.
Robert Manufacturing	Self Closing Barrel Faucets	Info@robertmfg.com	03rd august	Spanish RC	none
Tyco Waterworks	Talbot	wwinfo@tyco-valves.com	10th June	all	Have sent 1 * 2 items.
Scan water	Hi flo tap	Steinar Langedahl steinar.langedahl@scan-water.com	10th June	UNICEF, United nations, Norwegian Church Aid, World Vision, International Rescue Committee, UNHCR, IFRC	Were not interested.

Appendix 6: Previous discharge study from MSF France

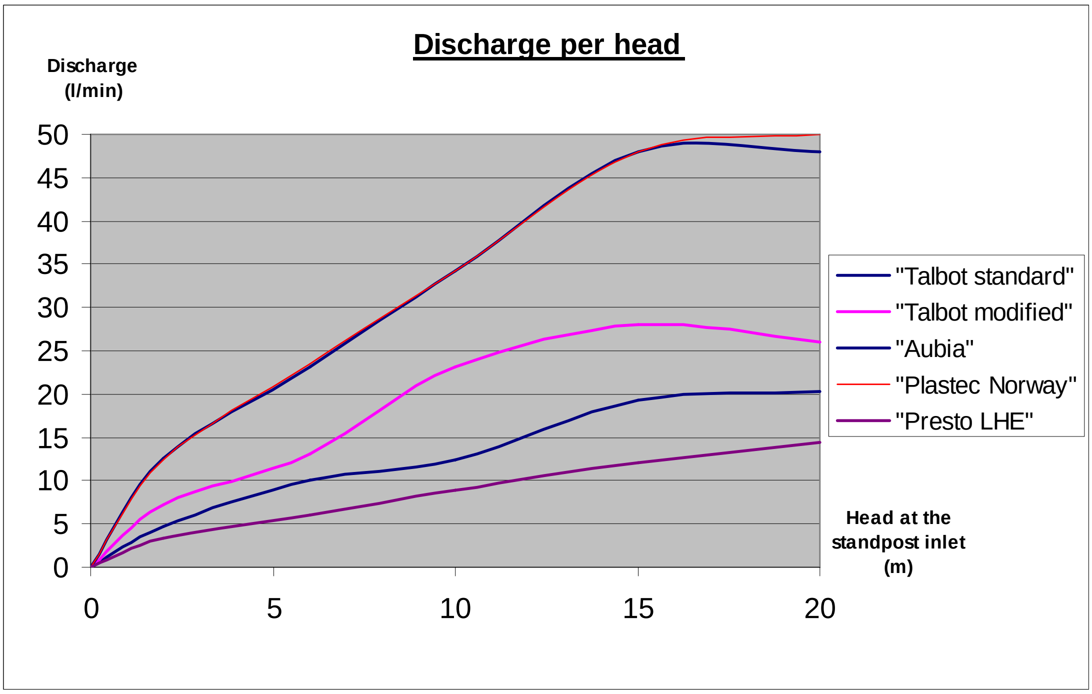
Appendix 6.1: Discharge table

Inlet Standpost Head (m)	Discharge (l / min)				
	"Talbot standard"	*"Talbot modified"*	*"Aubia"*	*"Plastec Norway"*	*"Presto LHE"*
0	0	0	0	0	0
2	4.7	7.1	12.6	12.5	3.3
6	10.0	13.0	23.1	23.5	6.0
10	12.4	23.1	34.3	34.3	8.8
15	19.4	28.1	48.0	48.0	12.0
20	20.3	26.1	48.0	50.0	14.5

(Isard 1995)

N.B 1: The head was determined thanks to a pump and a non-accurate manometer (Isard 1995).
N.B 2: There is no data about the "Talbot modification".

Appendix 6.2: Resultant graph



Appendix 7: Laboratory phase photos.

Appendix 7.1: Tower of the experiment

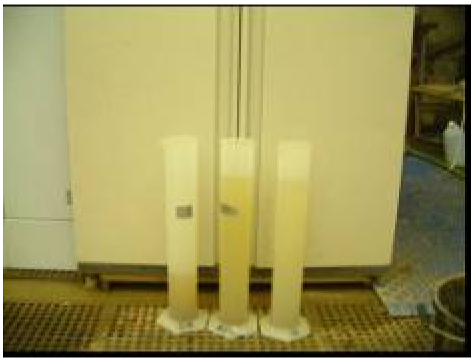
Appendix 7.2: OXFAM standpost

Appendix 7.3: Tank position and valve

Appendix 7.4: One inch pipe used

Appendix 7.5: Leakage at low pressure

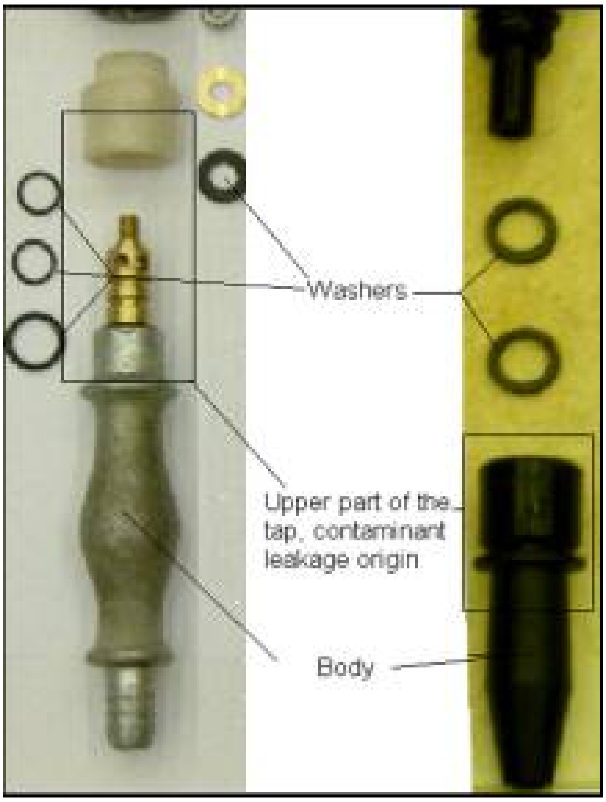
Appendix 7.6: Measuring cylinders



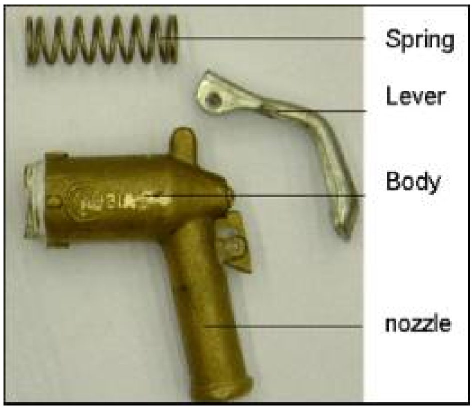
Appendix 7.7: Force measurement

Appendix 7.8: "Prestex" spare parts

Appendix 7.9-7.10: : "Even Product" Gravity flow taps and "Scat" spare parts



Appendix 7.11: "Aubia" spare parts



Appendix 7.12: "Talbot" spare parts

(even product spare parts equivalent)

Appendix 7.13: "SCAT" tie up

Appendix 7.14: "Even Product" gravity flow tie up

Appendix 7.15: "Talbot" tie up

Appendix 7.16: "Aubia" tie up

Appendix 7.17: "Even Product" push tap tie up

Appendix 7.18: "Prestex" tie up

Appendix 7.19: "Even Product" push tap modified

7.20: "Prestex" modified

Appendix 7.21: Direct push tap

Appendix 7.22: Indirect push tap

Appendix 7.23: Push system to avoid

contamination

contamination

contamination

Appendix 7.24: Gravity flow tap contamination

Appendix 7.25: "Gun position"

Appendix 7.26: "Grasp position"

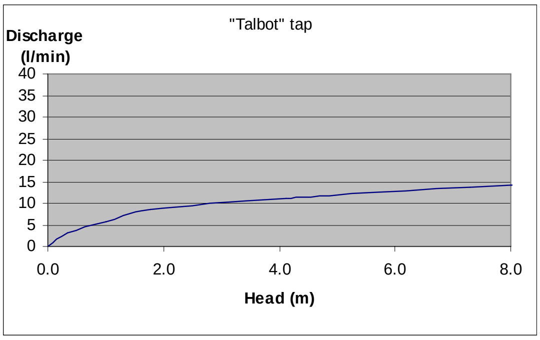
Appendix 7.27: Contamination experiment materials

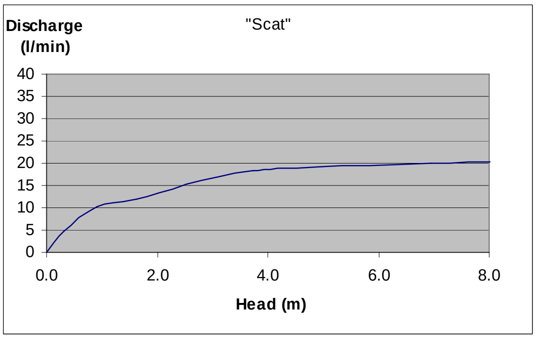
Appendix 7.28: Porridge and inoculum mixing

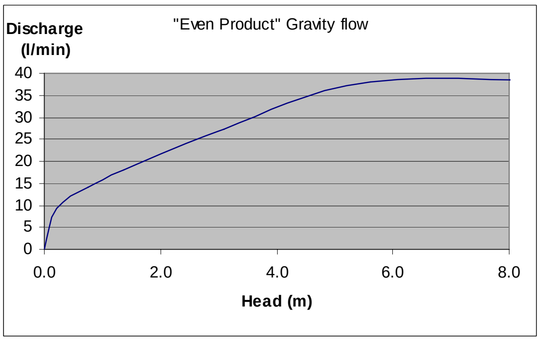
Appendix 7.29: Experimental protocol

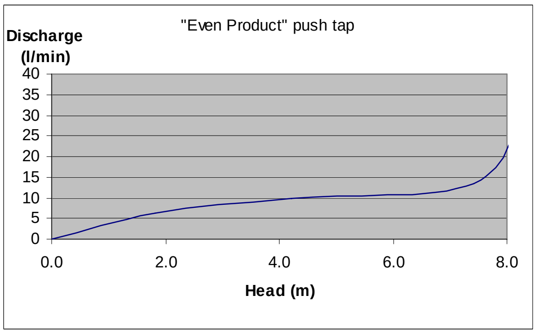
Appendix 8: Laboratory discharge results.

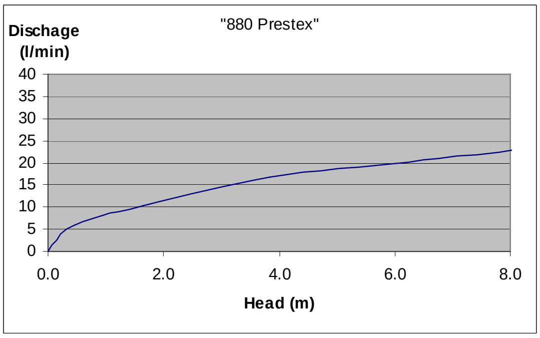
Appendix 8.1: tap discharge from 0 to 8 m of head at the tap inlet

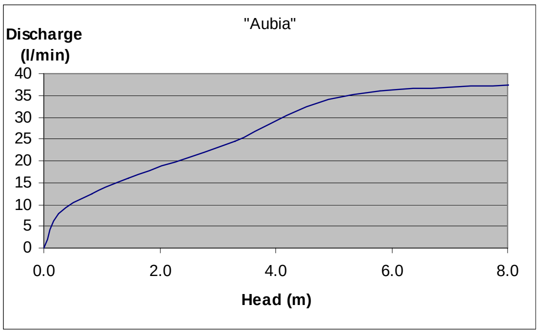


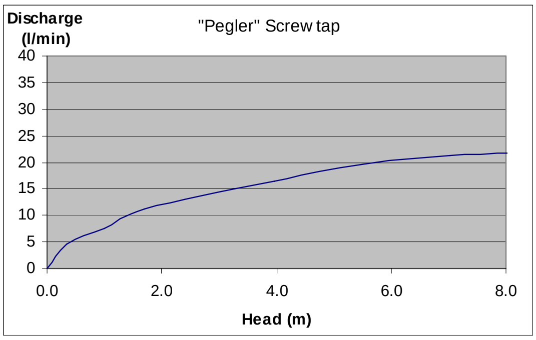


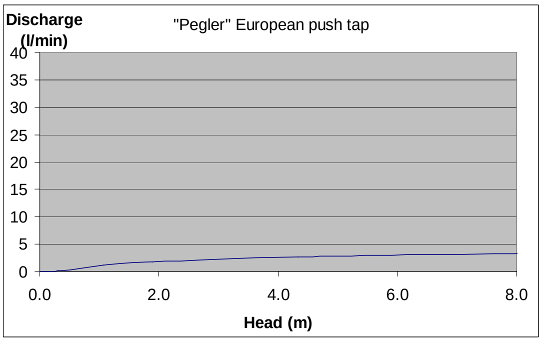












Appendix 8.2: Minimum Tap inlet head to reach the 7.5 l / min of minimum discharge (Sphere guideline 2000)

Taps	"Talbot"	"Even Product" gravity flow	"Even Product" Push tap	"Scat"	"Aubia"	"880 Prestex"	"Pegler" screw tap	"Pegler" European Push tap
Total head	**1.30 m**	**0.15 m**	**2.20 m**	**0.60 m**	**0.20 m**	**0.80 m**	**1.00 m**	**35 m**

Appendix 8.3: Detail of the Discharge results in function of the head at the inlet of

- *The elevation of the tank is the manometer indication (situated at the stanpstand inlet) when there where no flow on the pipe (1"diameter, 10 m length). This is equal to the total head.*

- *The tapstand inlet head is the manometer indication when there is a flow. It includes the total head subtracted by the linear head lost on the 1" pipe. An important remark during the practical has been that, with flexible pipe, the head lost calculated has often been half of the real one.*

- *The singular head lost (Hs) are due to four different bends on the tapstand and has been determined thanks to the "momento d'hydraulique" (Julien-laferriere 2003):*
Hs = 4 * 0.15 v² /2g = 4* 0.15 (discharge (m³/s)*4 / (π * pipe diameter (m) ²)) ² / 2 g

- *The tapstand linear head lost has been determined thanks to the Hazen-William equation:*
Hl = 10.69* (length pipe* ((Discharge/(60000*150))^1.852) * (Diameter pipe^-4.87)

Appendix 8.3.1: "Talbot"

elevation of tank (m)	0.8	1.17	1.88	2.7	5.15	8.43	49
Tapstand inlet head (m)	0.8	1.15	1.83	2.61	4.99	8.22	28.5
Tapstand singular head lost (m)	0.00	0.00	0.00	0.00	0.00	0.01	0.02
Tapstand linear head lost (m)	0.00	0.01	0.02	0.05	0.08	0.12	0.38
Tap inlet head (m)	**0.0**	**0.3**	**1.0**	**1.8**	**4.1**	**7.3**	**27.3**
Discharge (l/min)	**0**	**3.2**	**5.8**	**8.5**	**11.2**	**13.8**	**26.1**

Appendix 8.3.2: Gravity flow "Even Product"

elevation of tank (m)	0.8	1.17	1.88	2.7	5.15	8.43
Tapstand inlet head (m)	0.8	1.08	1.68	2.37	4.33	7.2
Tapstand singular head lost (m)	0.00	0.00	0.01	0.01	0.02	0.04
Tapstand linear head lost (m)	0.00	0.06	0.12	0.19	0.41	0.75
Tap inlet head (m)	**0.0**	**0.2**	**0.8**	**1.4**	**3.1**	**5.6**
Discharge (l/min)	**0**	**9.3**	**14.2**	**18**	**27.2**	**38**

Appendix 8.3.3: Push tap "Even Product"

elevation of tank (m)	0.8	2.7	5.15	8.43	49
Tapstand inlet head (m)	0.8	2.64	5.09	8.34	9.8
Tapstand singular head lost (m)	0.00	0.00	0.00	0.01	0.03
Tapstand linear head lost (m)	0.00	0.03	0.06	0.11	0.60
Tap inlet head (m)	**0.0**	**1.8**	**4.2**	**7.4**	**8.4**
Discharge (l/min)	**0**	**6.4**	**9.8**	**13.4**	**33.5**

Appendix 8.3.4: “Scat”

elevation of tank (m)	0.8	1.17	1.88	2.7	5.15	8.43	49
Tapstand inlet head (m)	0.8	1.13	1.79	2.52	4.74	8	25
Tapstand singular head lost (m)	0.00	0.00	0.00	0.00	0.01	0.01	0.02
Tapstand linear head lost (m)	0.00	0.02	0.07	0.09	0.20	0.23	0.38
Tap inlet head (m)	**0.0**	**0.3**	**0.9**	**1.6**	**3.7**	**7.0**	**23.8**
Discharge (l/min)	**0**	**4.8**	**10.2**	**12**	**18.4**	**20**	**26.2**

Appendix 8.3.5: “Aubia”

elevation of tank (m)	0.8	1.17	1.88	2.7	5.15	8.43
Tapstand inlet head (m)	0.8	1.1	1.73	2.43	4.46	7.33
Tapstand singular head lost (m)	0.00	0.00	0.00	0.01	0.02	0.04
Tapstand linear head lost (m)	0.00	0.04	0.09	0.15	0.33	0.68
Tap inlet head (m)	**0.0**	**0.3**	**0.8**	**1.5**	**3.3**	**5.8**
Discharge (l/min)	**0**	**7.8**	**12.4**	**16**	**24.4**	**36**

Appendix 8.3.6: “880 Prestex”

elevation of tank (m)	0.8	1.17	1.88	2.7	5.15	8.43	49
Tapstand inlet head (m)	0.8	1.135	1.78	2.53	4.82	7.83	15
Tapstand singular head lost (m)	0.00	0.00	0.00	0.00	0.01	0.01	0.03
Tapstand linear head lost (m)	0.00	0.02	0.04	0.07	0.17	0.25	0.52
Tap inlet head (m)	**0.0**	**0.3**	**0.9**	**1.7**	**3.8**	**6.8**	**13.7**
Discharge (l/min)	**0**	**5**	**8**	**10.4**	**16.8**	**21**	**31.1**

Appendix 8.3.7: “Pegler screw tap”

elevation of tank (m)	0.8	1.17	1.88	2.7	5.15	8.43
Tapstand inlet head (m)	0.8	1.145	1.83	2.59	4.935	8.1
Tapstand singular head lost (m)	0.00	0.00	0.00	0.00	0.01	0.01
Tapstand linear head lost (m)	0.00	0.02	0.04	0.08	0.16	0.26
Tap inlet head (m)	**0.0**	**0.3**	**1.0**	**1.7**	**4.0**	**7.0**
Discharge (l/min)	**0**	**4.6**	**7.6**	**11.2**	**16.4**	**21.2**

Appendix 8.3.8: "Pegler" European push tap

elevation of tank (m)	0.8	1.17	1.88	2.7	5.15	8.43	50
Tapstand inlet head (m)	0.8	1.16	1.87	2.69	5.14	8.42	49
Tapstand singular head lost (m)	0.00	0.00	0.00	0.00	0.01	0.01	0.04
Tapstand linear head lost (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tap inlet head (m)	**0.0**	**0.4**	**1.1**	**1.9**	**4.3**	**7.6**	**48.2**
Discharge (l/min)	**0**	**0.2**	**1.2**	**1.7**	**2.6**	**3.2**	**8**

Appendix 9: Force, jet, and tie up study

In this appendix, E.P 1 is the "Even Product" gravity flow tap, and E.P 2 is the "Even Product" push tap.

Appendix 9.1: measure of the force exerted to turn on taps

Water Head	Talbot	E.P 1	E.P 2	Scat	Aubia	880 Prestex	Pegler 883	Pegler screw tap
0.37	4.9	7.8	9.8	9.8	60.8	68.7	34.3	98.1
1.08	4.9	9.8	9.8	9.8	60.8	68.7	34.3	98.1
1.90	9.8	14.7	9.8	14.7	60.8	68.7	34.3	98.1
4.35	11.8	19.6	9.8	17.7	60.8	68.7	34.3	98.1
7.63	25.5	49.1	9.8	25.5	60.8	68.7	34.3	98.1
49.00	157.0	215.8	117.7	39.2	127.5	68.7	34.3	98.1

N.B: *It is difficult to compare the force used on a push tap and the one used on a gravity flow tap as gravity flow taps are more difficult to turn on than push taps at same force.*

Appendix 9.2: Diameter (cm) of the jet measure

High of water	Talbot	E.P 1	E.P 2	Scat	Aubia	880 Prestex	Pegler 883	Pegler screw tap
8.43	11.0	7.0	6.0	2.0	8.0	9.0	2.0	35.0
With modification (appendix 7.19 – 7.20)			4.0			6.0		

Appendix 9.3: Tie up time needed with an iron string (s)

Items	Talbot	E.P 1	E.P 2	Scat	Aubia	880 Prestex	Pegler 883
Time needed (s)	28	25	60	25	25	100	150

Appendix 10 contamination risk determination

Appendix 10.1: Contamination risks of the different taps.

Items	Risks
Gravity flow taps	Studied in the following table 10.2
Lever push taps ("Aubia")	None observed
Handle push taps (Even Product type)	High in bad hand position (appendix 7.21) may leak as in appendix 7.22
"Prestex" push tap	None observed especially thanks to the form of the handle (Appendix 7.23)

Appendix 10.2: The contamination of water with gravity flow taps collected in 10 litre bucket with 5 m of head at the tap outlet.

Items	"Old Scat"	"New Scat" (only few uses by the university)		"New Talbot" (only few uses by the university)		"Even Product" without grease		"Even Product" with grease	
Position	gun	gun	grasp	gun	grasp	gun	Grasp	gun	grasp
Time considered to fill a 10l tank (s)	30	30		45		15		15	
quantity (ml)	510	12.5	11	5.5	2	5.5	5.5	0	0
E. coli concentration / ml borehole water	1.8.E+04								
e. coli concentration / ml	2.0.E+04	3.7.E+04	3.0.E+05	1.1.E+04	6.7.E+04	4.1.E+04	1.1.E+06	-	-
Concentration increase from borehole water	2.0.E+03	1.9.E+04	2.8.E+05	-	4.9.E+04	2.3.E+04	1.1.E+06	-	-
Concentration expected in the 10 litre bucket in E. coli / ml	102	24	310	-	10	13	595	-	-

Comments:

- *According to this study, with the "grasp position" (Appendix 7.26), the water is much more contaminated than with the "gun position" (Appendix 7.25). However, there is still contamination, even with new materials: 24 E. coli /ml with the new Scat, and 10 E. coli / ml with the new Talbot.*

- *The new 'Even Product' did not leak at all due to the grease barrier between the body and the plastic part of the tap. When it is removed, the even product leaks constantly from the upper part, which creates a serious contamination risk: the surface of the body of the tap is already covered in water, when the palm of the hand is applied this water runs through the entire palm. Because of its contact with the palm, which usually carries the highest Coliforms concentration, these drops are much more contaminated than if the water comes contact with the back of the hand (as in grasp position without constant leakage prior to use). This is the reason of the important contamination for the even product*