STOP THE ROT

Overview of handpump corrosion and maintenance challenges for a sustainable drinking water supply for rural populations in Cameroon - Case study of twenty pumps

Action-research on the corrosion and quality of handpump components in Sub-Saharan Africa

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Table of contents

List of images

List of illustrations

List of tables

Abbreviations and Acronyms

ACRONYMS	MEANING
AFD	French Development Agency
ANOR	Agency for Standards and Quality
AfDB	African Development Bank
ARMP	Public Contracts Regulatory Agency
CAMWATER	Cameroon Water Utilities Corporation
CBO	Community-Based Organizations
FCFA	West Africa CFA Franc
ENSPM	Ecole Nationale Superieure Polytechnique of Maroua [National Higher Polytechnic Institute of Maroua]
FEICOM	Special Council Support Fund for Mutual Assistance
GDWQ	Guidelines for Drinking-Water Quality
GWI	Global Water Initiative
GWP-CAF	Global Water Partnership – Central Africa
GWP-Cm	Global Water Partnership - Cameroon
JMP	Joint Monitoring Programme
MINDDEVEL	Ministry of Decentralization and Local Development
MINEE	Ministry of Water and Energy
MINTP	Ministry of Public Works
NGO	Non-governmental organisation
PANGIRE	National Action Plan for Integrated Water Resources Management
pH	Potential of Hydrogen
PIB	Public Investment Budget
PNDP	National Community-Driven Development Programme
RMS	Remote Monitoring System
RWSN	Rural Water Supply Network
SDN	National Development Strategy 2020-2030 in Cameroon
SOLDIS	Solidarity for Development and Public Health Initiatives
SSA	Sub-Saharan Africa
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization

Summary

In January 2021, Ask for Water GmbH and Skat Foundation, through the Rural Water Supply Network (RWSN), launched the "*Stop the Rot*" initiative for boreholes with handpumps. Its purpose was to provide an overview of the extent of the phenomenon of rapid corrosion of handpumps and the challenges of the maintenance operations of these structures for populations in rural and peri-urban areas. This RWSN Stop the Rot study targeted 20 countries in sub-Saharan Africa (SSA), including Cameroon.

To better understand this phenomenon, a qualitative study at the local level in Cameroon was undertaken, combining deductive and inductive approaches through direct observations, exchanges with key informants and a literature review. The observations were made on a relatively small number of handpumps (twenty pumps) due to the limited resources available for this study.

Documentation on this subject has been scarce in Cameroon, except for that of Furey (2013), and also cannot be found in certain research institutes and specific universities, or even in the grey literature, which attests to the originality of this issue. In fact, the phenomenon of the rapid corrosion of handpumps which is presented as one of the main factors behind the poor quality of the water supplied by the pumps, is still not the object of great scientific curiosity on the part of the local researchers, although it has been known in Africa for more than 30 years according to this same Network.

However, the contrast between the scarcity of these research topics and the evidence for the existence of this phenomenon in the field was noted. In fact, in Foumbot (Western Region), the existence of the phenomenon of rusty pumps was observed. Even though it has not been possible to identify the reports of technical and sanitary audits that have been carried out regarding handpumps in Cameroon, users of these types of facilities have reported situations of concern for their health due to the rusty-smelling water that they are constantly consuming. The majority of the technicians that are generally mobilized for handpump maintenance attributed the defects in the functionality of the pumps in certain cases to non-compliance with the quality standards of the materials that are being used. As a result, it has been noted that there is virtually a complete lack of standards from the Agency for Standards and Quality (ANOR) on the specific standards for materials for handpumps in Cameroon. Handpumps are imported mainly from India, China and neighbouring Nigeria in a market controlled exclusively by the private sector.

In the hardware stores visited, the study team was told that there is a gradual trend towards the use of electric pumps (diesel, gasoline, solar) in rural areas. Except that this trend is still weak compared to the impressive number of new handpumps that are being installed, especially the India Mark II brand that seen in these areas. This is despite the notorious functionality flaws that sometimes require major repairs just a few days after their installation. On the other hand, the study team believes that the rapid deterioration of the pumps is mainly due to the aggressiveness of the water or the type of rock, the use of poor quality materials, the limited financial resources available for the installation of these structures in some cases. Further, some contractors who would prefer low-cost materials when executing contracts to install handpumps to make cut costs. In order to solve this problem in Cameroon, this study recommends:

- Mapping the areas with a high risk of handpump corrosion in the 10 regions of Cameroon based on certain bio-physical-chemical parameters of the groundwater.
- A specification of norms and standards on the quality of materials to be imported and marketed by local suppliers of handpump materials and accessories. These standards in addition to those of the RWSN should also reflect the WHO Guidelines for Drinking Water Quality (GDWQ) (WHO, 2017).
- A map of existing handpumps to better monitor their functionality as well as setting up maintenance operations for these infrastructures in a participatory manner with Community Based Organizations (CBOs) and municipalities.
- Consideration of the resources required for the operation of the installed handpumps.
- The use of innovative technologies to monitor the service level of the pumps, especially in certain institutional centres (hospitals and schools) where a large number of them installed are in Cameroon.
- Solar panel boreholes as an alternative to handpumps in these rural areas. The government and its development partners should direct more funding to these infrastructures and take the maintenance costs into account so that they are compatible with the population's income and their performance.

Introduction

Cameroonians are suffering from a growing lack of access to drinking water. Access to drinking water for urban and rural populations remains a major challenge. According to the National Institute of Statistics (NIS, 2018), the average rate of access to basic drinking water for the population was 77% in urban areas and 45% in rural areas. This situation had not changed significantly by 2022. As a result, populations often turn to water from wells and boreholes, including handpumps (Adoua KOPA, 2012).

In January 2021, *Ask for Water GmbH* and the *Skat Foundation*, as part of their collaboration under the Rural Water Supply Network (RWSN), launched a 15-month initiative to document the magnitude and the extent of the rapid corrosion of handpumps and the use of poor-quality components in Sub-Saharan Africa (SSA), in order to take appropriate action to address these issues. Danert (2022a) found that these two interrelated problems contribute to poor handpump performance, rapid failure, and poor water quality. These are all factors that can ultimately lead to the abandonment of sources equipped with handpumps, forcing users to return to distant water supply sources. This initiative is called "*Stop the Rot*"

This is certainly one of the main obstacles to achieving the Sustainable Development Goals (SDG-6) in SSA. It is also one of the challenges that need to be overcome urgently in these countries, including Cameroon, where the lack of drinking water supply from the public network (CAMWATER) is largely compensated for by installing handpumps in several municipalities through certain government projects, national/international development partners and some individuals. Unfortunately, the effectiveness of these projects is being increasingly questioned because of the poor quality of the structures that have been installed and, therefore, of the water that is being supplied to the population.

For this reason, the present study in Cameroon called "Stop the Rot" was undertaken. The Stop the Rot report attempts to give an account of the extent of the phenomenon in some rural and peri-urban areas, sampled respectively in the Far North and West regions (Kousseri, Foumbot) of Cameroon as follows:

- The general state of affairs of the water sector in Cameroon.
- An inventory of the problems that are causing handpumps to malfunction.
- A diagnosis by the stakeholders involved in selling the pump materials.
- How the corrosion phenomenon is perceived by the people who install the pumps, the populations who benefit from them, the financiers.
- The prospective analysis of handpump financing, the alternatives for optimal operation of the handpumps and the challenges that may arise.

1. Study framework & context

Cameroon, located in Central Africa, is a lower middle income country with an estimated annual Gross Domestic Product (GDP) of 3.5% (World Bank, 2021). From an economic point of view, Cameroon has defined its course, and its vision for 2035. Looking at the documents and/or programs in progress, in particular the National Development Strategy 2020-2030 (NDS-30), the activities related to water and sanitation, are mentioned, but are limited to improving access to water and sanitation, while ignoring the other water sub-sectors. As a result, water in Cameroon is still far from being placed at the heart of the economic and social development process (GWP-Cm, 2010).

In terms of governance, except for the many different documents and speeches describing the elements of sectoral policies, Cameroon does not have a formal national water policy. This sector is made up of a plethora of actors, lacking coordination, as well as poor positioning of the main actor: the Ministry of Water and Energy (MINEE). As far as rural water supply is concerned, a national policy that defines the principles of intervention has been drawn up with the financial support of the Agence française de développement (AFD). However, without sufficient financial resources, this document has not initiated any significant reform in this sector. The Urban Water Sector Policy Letter, drawn up in 2007, defines the authorities' commitments in terms of urban water supply. Information on water and sanitation remains incomplete. This situation is due to insufficient monitoring and evaluation of water resources, data collection, processing and management. In addition, there is a lack of human resources in this sector, sometimes they are less qualified in innovative technologies, coupled with the limited availability of standards or non-compliance with the existing ones without any possibility of sanctions for violators (GWP-Cm, 2010; PSEau, 2013).

Cameroon has enormous water resources. The surface area of the country is 267.88 km with 32.52 km^2 for the Lake Chad basin, 43.91 km^2 for the Niger basin, 63.18 km^2 for the Sanaga basin, 33.45 km^2 for the Congo basin and 94.82 km^2 for the Coastal Rivers basin.

Groundwater resources with a volume of 55.98 km^3 are divided between two main types of geological formations: sedimentary formations and the basement area. During the dry season in many rural areas, the demand for surface water exceeds the supply and a large portion of this population relies on groundwater (Upton, 2018). In terms of literature on the iron content of groundwater, the rock in the Mudeka area (South West) where it has been reported that pumps are providing rusty water, has a diversity characterized by the dominance of ferralitic soil, hydromorphic soil, undeveloped soil and raw mineral soil (Adoua KOPA, 2012). Among these ferralitic soils, we have noted that the yellow ferralitic soils, derived from sandy and sandy-clay sedimentary rocks, are dominant. The base content of these rocks is very low and their pH level is acidic (on average pH 5.5).

Demographically, the population of Cameroon in 2021 was estimated at 27 million inhabitants. The country is experiencing a rapid urbanization with an estimated urban population growth rate of 3.5% (World Bank, 2021) with 55% inhabitants living in urban areas and 45% in rural areas (GWP-Cm, 2010). This rapid urbanization of the population does not go hand in hand with the development of basic infrastructure such as access to water, which remains limited (Adoua KOPA, 2012).

In terms of statistics on waterborne diseases, intestinal helminthiasis affected more than 10 million Cameroonians between 2003 and 2006. With an average health expenditure per household per month of 7,854 CFA francs, which represents 29% of the average income estimated at 26,800 CFA francs, the burden of diseases related to poor water and lack of sanitation was 70%. The annual expenditure on waterborne diseases per household was estimated at 65,975 CFA francs (GWP-Cm, 2010).

2. The problems with handpumps: literature review

2.1. Types of handpumps

There are several types of handpumps available on the market around the world. The Stop the Rot studies focused on two public domain community handpumps – the India Mark II (or variants thereof) and the Afridev. The studies also incorporated lessons learned from the Bush Pump, which is used almost exclusively in Zimbabwe. Figure 1 shows the pump heads for these three handpumps.

(a) India Mark II
Source : Karl Erpf.

(b) Afridev
Source : Karl Erpf.

(c) Zimbabwe Bush Pump
Source : Peter Morgan.

FIGURE 1 : THE THREE MAIN PUMP HEADS OF THE MOST COMMONLY USED HANDPUMPS.

EXCERPT FROM: DANERT, K. (2022A)

The India Mark II pump is a robust conventional lever action handpump, designed for heavy-duty use, each pump can serve a community of about 300 people. The maximum recommended lift is 50 m. This is a public domain pump that meets the technical specifications of Skat Foundation and RWSN (2007b) and the Bureau of Indian Standards (BIS, 2004). Its installation and maintenance require special skills and it is not considered suitable for maintenance at the village level.

The Afridev Pump is a conventional lever action handpump. It is designed for heavy-duty use, each pump can also serve a community of about 300 people. The maximum recommended lift is 45 m. The Afridev pump is a public domain pump that meets the technical specifications of Skat and RWSN (2007a). It was designed in such a way that it could be maintained by the community itself, without outside intervention.

The Bush Pump is a robust conventional lever action handpump, developed in Zimbabwe and meets the Zimbabwean standards (Government of Zimbabwe, 2013). It is designed for heavy-duty use, and each pump can serve a community of about 300 people. There are three different cylinders available, the smallest extending the reach to a maximum recommended lift of 80 m. The Bush Pump requires special skills for installation and maintenance.

Sutton and Butterworth (2021) estimate that 6.2% of the population of sub-Saharan Africa has an improved groundwater supply (i.e. borehole or protected well) at the household level, which is usually shared with neighbours. Since these pumps tend to be used by fewer people than community sources, they don't need to be as robust as community pumps. Some self-supply users will therefore use rope pumps or other low-lift pumps, while others will use motorized pumps, relying on solar energy or other sources such as diesel, petrol or the electrical grid.

2.2. Use of groundwater points in Cameroon

National surveys and censuses regularly collect data on groundwater sources (tube wells/boreholes and protected/unprotected wells and springs). These national estimates are then compiled by the JMP (WHO and UNICEF, 2021a). Based on the most recent survey/census estimates compiled by the JMP for each country, Danert (2022a) estimates that 50% of the total population of sub-Saharan Africa, about half a billion people depend on protected or unprotected groundwater points for their primary drinking water supply. In Cameroon, about 57% of the population depends on groundwater points (above average for SSA).

2.3. Use of boreholes and protected wells in Cameroon

Based on further analysis of JMP estimates (WHO and UNICEF, 2021a), Danert (2022a) estimates that 20.8% of the total population in Sub-Saharan Africa uses a borehole, and 3.8% uses a protected well as their main source of drinking water, which is 24.6% in total. Danert (2022a) estimates that 35% of the rural population in Cameroon depends on boreholes and protected wells.

2.4. Estimated number of handpumps in Cameroon

In order to estimate the number of handpumps installed in SSA, Danert (2022a) considered three national scenarios in which, on average, handpumps serve 150, 250 or 400 people. By comparing the estimates from this study with the most recent comprehensive estimates of the number of handpumps collected by Foster et al. (2019) and others, one of these three scenarios was selected for each country. Danert (2022a) thus estimates that each water point that consists of a handpump and is installed in Cameroon serves an average of 400 people.

Danert (2022a) estimates that the number of handpumps used as the main source of drinking water supply in sub-Saharan Africa is between 0.5 and 1.3 million. Based on the assumed scenarios for each country, the most likely number of handpumps that are being used as the primary source of drinking water is 0.7 million.

Another study conducted by Foster et al. (2019) in Cameroon, for 189 out of 316 municipalities, estimated the number of installed handpumps to be around 6899, of which 32% were not functional.

2.5. Challenges for the optimal use of handpumps in Cameroon

Even though we are seeing more and more solar and electric pumped boreholes in Cameroon, the majority of water supply projects still prefer handpumps.

As a result, one of the very first challenges besides the "*quality*" standards required at the time of awarding and executing the contracts after their installation, will be to continually collect information on the functionality of these handpumps. These time-based indicators have become the norm in many countries. The most recent comprehensive data on handpump functionality rates for 38 countries in SSA was released in 2019. It was estimated that, on average, one in four handpumps were not functioning at any time, ranging from 11% in Burkina Faso to 30% in Togo and the Côte d'Ivoire (Foster et al., 2019). Equivalent statistics for Cameroon were not available.

The second major challenge in Cameroon is to determine the underlying cause of the poor performance or failure of handpumps in the areas where they are installed. Danert (2022a) found that there are numerous causes for handpump functionality defects. In his study, water point failures were linked to a variety of characteristic critical factors and issues, including the existence of a village committee, spare parts, collecting money for maintenance from the community, a trained mechanic/handpump attendant, and seasonal supply.

A study report on the installation of handpumps in Cameroon (MODEAME, 2021) presents four major points that need to be outlined and explained to the population during training campaigns for members of the management committees and regarding the water code, namely:

i. Water is a public good.
ii. Providing drinking water and access to sanitation is a communal public service.
iii. There is a charge for water and the applicable rates must take the users' ability to pay into account and must allow for the full recovery of the operating costs.
iv. Operation can be carried out directly or delegated to managers through management, leasing or concession contracts.

The third major challenge in Cameroon is to set up maintenance operations for boreholes equipped with handpumps. For companies operating in this sector, maintenance plans must, among other things, take the underlying causes of poor performance or handpumps malfunctioning in different areas into account. Conversely, some of these underlying causes also have an impact on the sustainability of the maintenance operations. This is the case for water point management models where the charges to be paid by each household must cover the financial costs of routine operation and maintenance, including minor repairs and cases of major repairs, including replacing spare parts (GWI, 2012).

Due to the immense repair costs, the latter case would even require external financial contributions from the local government, municipalities, NGOs, etc. These maintenance costs must therefore be budgeted for consistently on an annual basis. In this research, the estimated management costs of the summarized handpumps could not be found, so they were replaced with costs for Burkina Faso, a country comparable to Cameroon from a socio-economic point of view.

TABLE 1: THE THREE MAIN TYPES OF COSTS GENERATED BY A MODERN WELL EQUIPPED WITH A HANDPUMP.

What?	How much?	When?	Who finances it?
Investment cost for a modern well equipped with a handpump. (Capital Expenditure: CapEx)	Approx. 8,500,000 CFA Francs ($ 17,000 US) in Burkina Faso for a 30 m well.	Punctual (at the beginning)	Costs are shared between external donors and the community.
Routine operating and maintenance costs including minor repairs. (Operation and Maintenance Expenditure: OpManEx).	Approx. 140,000 CFA Francs (US $280) / year in Burkina Faso for an India Mark II pump + well maintenance costs.	To be taken into account from the first day	Community
Major repairs and replacement of spare parts. (Capital maintenance expenditure: CapManEx)		From the 5th or 7th year	Community, municipality and other external support

EXCERPT FROM: GWI Technical Series (2012).

This information can be completed by the information provided by Bérenger T. (2013) in Cameroon. In his study he estimates an average cost of 5,000,000 CFA Francs (US $8,400), and the contribution of various factors to achieve such a project, of which the details are provided below.

TABLE 2: THE CONTRIBUTION OF VARIOUS FACTORS TO THE COST OF BUILDING A MODERN WELL WITHIN THE FRAMEWORK OF THE "WATER IS LIFE" PROJECT.

Factor	Amount in CFA Francs - per well	Contribution to the overall cost of a project
Administrative costs and salaries	765,000	15.3%
Facilitation	100,000	2 %
Prospecting	80,000	1.6%
Manufacturing nozzles	1,150,000	23%
Fuel and maintenance of vehicles and machines.	735,000	14.7%
Well construction	850,000	17%
Handpumps	710,000	14.2%
Depreciation	600,000	12%
Total	**5,000,000**	**100%**

EXCERPT FROM: Bérenger T. (2013).

3. Persistent funding for the installation of handpumps in Cameroon and the urgent need for market standardization

3.1. Main sources of funding for handpumps in Cameroon

From a series of publications in the main government newspaper (Cameroon-Tribune, 2021), the actors who are mostly involved in funding drinking water supply projects in Cameroon were identified. Most of these were announcements of financial support from government organizations (specifically those in charge of development) or calls for tenders to carry out these contracts in certain municipalities (Table 3).

TABLE 3: THE MAIN ORGANIZATIONS THAT DIRECTLY OR INDIRECTLY FUNDED THE INSTALLATION OF HANDPUMPS IN CAMEROON IN 2021.

National Organizations	International Organizations
Special Council Support Fund for Mutual Assistance (FEICOM)	World Bank (WB)
National Community-Driven Development Programme (PNDP)	Global Water Partnership (GWP)
Ministry of Decentralization and Local Development (MINDDEVEL)	African Development Bank (AfDB)
The Ministry for Water and Energy (MINEE)	United Nations Organizations (e.g. UNICEF, UNDP, UNHCR)
The Ministry of Public Works (MINTP)	Luxembourg Red Cross
Municipalities within the framework of the Public Investment Budget (BIP)	Norwegian Refugee Council (NRC)

EXTRACT FROM: Cameroon-Tribune (2021).

This is without counting certain organizations and individuals who do not always follow the same procedures for the installation of handpumps.

3.2. Main companies involved in selling pumps in Cameroon

The list of organizations that import handpumps or their accessories into Cameroon is long. In this market you will only find privately owned companies made up of medium and small hardware companies that either buy from large importers (materials from India, China, etc.) or that buy materials directly from neighbouring Nigeria.

3.3. Standards for handpumps in Cameroon

In Cameroon on November 12, 2019 Standard 2875 was adopted by the Agency for Standards and Quality (ANOR) on water, the water industry, the environment and water use. Standard 2875 specifies the general performance, safety and durability requirements for the design and testing of prefabricated integrated treatment units for the benefit of manufacturers/stakeholders in the production of drinking water, consumers and public authorities (ANOR, 2015). However, the lack of specificity on handpump materials and accessories remains a problem.

3.4. Scientific research into the causes of pumps malfunctioning in Cameroon

Despite reviewing nearly 15 scientific publication sites, no specific literature could be found, other than (Furey, 2013), which refers to the Mudeka area (South West) and addresses the corrosion phenomenon of handpumps in Cameroon.The literature specific to the targeted areas of Foumbot (West) and Kousseri (Far North) focuses primarily on other issues, including the accessibility of drinking water.

Hydrology schools (e.g. ENSPM, ESIAC) were also identified in order to find local literature among the currently unpublished thesis subjects that address this topic. Unfortunately, the research remained unsuccessful at finding local literature.

This research subject on handpump corrosion is therefore original.

4. Questions and objectives of the study

4.1. Research Questions

In general, what is the extent of the problem of handpump corrosion in Cameroon, and what are the challenges of maintaining these structures to meet the Sustainable Development Goal targets for access to drinking water?

4.2. Goal and Objectives

Overall, the goal is to provide an overview of the handpump corrosion and the challenges of maintaining handpumps to meet the Sustainable Development Goals for access to drinking water in Cameroon. More specifically, the objectives are:

1. Conduct a review of the literature on the naturally high iron content of groundwater and the rapid handpump corrosion in Cameroon.
2. Identify the actors involved in the financing and implementation of projects that install and maintain handpumps in Cameroon in peri-urban and rural areas.
3. List the most common brands of handpumps in these peri-urban and rural areas of Cameroon.
4. Identify the main organizations or private companies that import handpumps into the country.
5. Document all the national standards that have been issued for handpumps in Cameroon.
6. Conduct brief surveys in targeted communities in the West and Far North, including the beneficiaries' opinion on the quality, reliability and acceptability of the water provided by these handpumps in these peri-urban and rural areas of Cameroon.

5. Methodology

5.1 General overview

To better understand the phenomenon of rapid handpump corrosion, the study has, in accordance with the different objectives, opted for a qualitative approach combining both inductive and deductive approaches, i.e.:

- A literature review of the factors that may contribute to the acceleration of handpump corrosion and handpump maintenance challenges.
- Field surveys (in-depth individual interviews, focus group discussions) with stakeholders (drilling companies, sales reps for handpumps, formal and informal maintenance agents, beneficiaries) supported by direct observations of 20 handpumps in the target areas.

This study focused on the regions of Kousseri (Far North) and Foumbot (West), which were chosen in a reasoned way (Appendix 1). These choices were justified by, for example, the large number of handpumps installed in these areas, the nature of the rock, complaints about the quality of the water from the pumps, especially those of which the populations around the structure suspected the rusty smell, and the statements of the maintenance agents.

Interviews and focus group discussions were conducted using an interview guide that was developed based on the specific objectives of the study. Each target group was given their own interview guide (Appendix 2). In order to compensate for any loss of information, a smartphone recorder was used for a complete and systematic backup of the exchanges.

In each of the targeted areas, we sampled ten (10) handpumps, mainly based on complaints from the populations about the quality of the pumped water.

The participants of this study were recruited around these structures, among the beneficiaries in the households (including community leaders, agents that collect the operating costs for the pumps).

Apart from these sites, vendors for handpumps and spare accessories in hardware stores, some craftsmen/mechanics in charge of handpump maintenance, and some contractors in the hydraulic sector (drilling companies) working in the field were interviewed.

Two (02) group discussions per site were conducted and six (06) in-depth individual interviews (online).

This study was conducted in Cameroon on a voluntary capacity, for RWSN, which initiated the research project "Stop the Rot". Given the intense activity of conducting it in Cameroon, this activity was conducted with the help of some volunteers recruited in the field, notably for the specific tasks of facilitating the focus groups, transcribing the verbatim reports, and assistance in writing the final report of the study.

5.2. Data collection procedure

Before going into the field, community leaders (administrative and traditional authorities) were met with in advance to explain the merits of the research work.

Ethical considerations were also taken into account before approaching each of the stakeholders spoken to. They were asked for informed consent, they were informed of the importance of providing their opinions on the quality of the water, the reliability and the acceptability of the water supplied by these handpumps in their locality, including any problems related to the maintenance costs of these structures.

The process of screening or selecting participants was done in the following way:

- Preparing invitation tickets with the context, place, date and time of the session concerned.
- Selecting local volunteer recruiters to identify participants and to update recruiters on the profile and quotas of participants.
- Distributing invitations to participants by volunteer recruiters and registering individual contacts.
- Reminding participants a few hours before the interview to make sure that we meet our quota.

5.3. Data processing

The data processing was done as it was collected in the field. At the end of each discussion session, a synthesis was prepared to summarize the collected data. Afterwards, verbatims of the interviews from the saved recordings were immediately transcribed. A content analysis of the comments based on the objectives, information categories and subcategories was undertaken. Statistical estimates and extrapolations were done afterwards.

5.4. Limitations of the study

Sampling of the selected sites was based on the existence of boreholes equipped with handpumps and the complaints of the populations around the water points who suspected the smell of rust during the preliminary interviews with the targets. Work was undertaken in two (02) out of the ten (10) existing regions, which is therefore not very representative of the quality of materials that is used in the Cameroonian territory. Further, biological and physico-chemical soil parameters that could influence handpump corrosion were not taken into account

6. Results of the Study

6.1. The most common pump brands in Cameroon and their origins

In the areas selected for this brief survey in Kousseri (Far North) and Foumbot (West), compared to the Afridev brand, the India Mark II brand (including Extra Deep Well) was the most common in the field (Figures 2 and 3). This was also clear from our observations in hardware stores and interviews with companies that import pumps and mechanics who served as key informants in the field. As anticipated, Bush Pumps were not installed in these areas.

As for their origins, the list of organizations that import handpumps or their accessories into Cameroon is long. It is a market that is exclusively controlled by private companies. These players are composed of large, medium and small companies (hardware stores) that either buy the materials from large importers (particularly from India and China) or rather, directly from neighbouring Nigeria.

In addition, companies that sell drilling materials have informed us that there is a growing interest in electric pumps (gasoline and diesel) or solar pumps in Cameroon. However, handpumps are still very much in demand in drinking water supply projects, especially in rural areas.

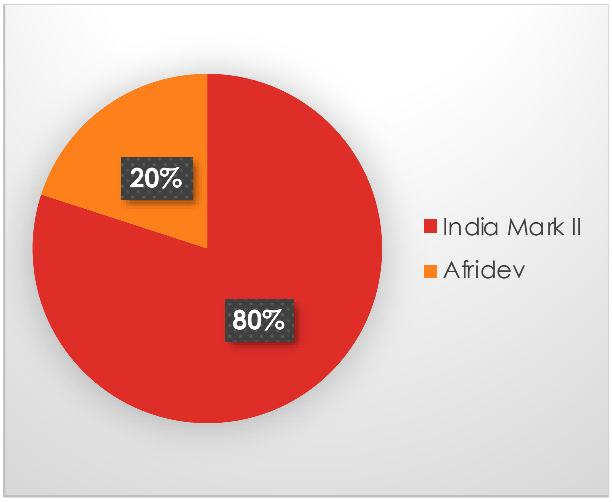

FIGURE 2: PUMP HEADS FOUND IN THE FOUMBOT AREA FROM 10 SAMPLED WATER POINTS.

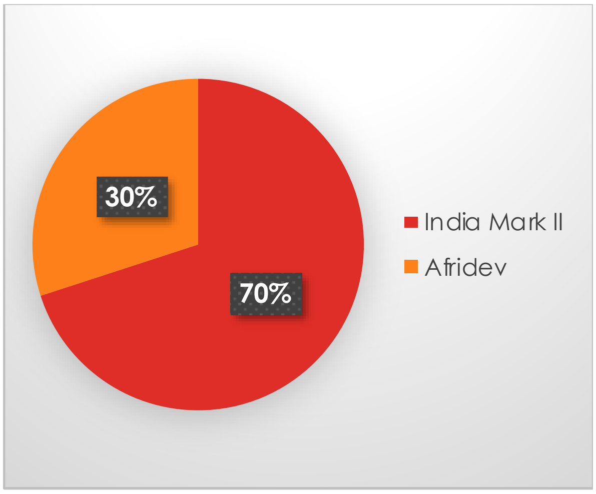

FIGURE 3: PUMP HEADS FOUND IN THE KOUSSERI AREA FROM 10 SAMPLED WATER POINTS.

6.2. Reasons for the use of poor quality materials and the consequences

Interviews with some key informants indicated that the use of poor quality materials would often be linked to contractors trying to make a profit when executing handpump installation contracts. Although it has been reported elsewhere, there may also be problems with small amounts of donor funding.

In this regard, one of the key informants stated: "… *On the market, you have everything. There is the real, there is the fake. And the real thing sells for a lot of money and the fake one for a lot less, for those who do it themselves. It all depends on the resources made available by donors or how committed the person who executes the contract is to the principles of quality materials or the quality of the structure…*". The latter case is used by the majority of governmental organizations and NGOs involved in installing pumps.

The majority of these handpumps consist of cast iron cylinders where the rod rusts in the water. It is important to say that the invisible part of the handpump consists of the cylinder, the pipe and the rod.

There are also operators who install the boreholes with stainless steel cylinders, which have less problems with corrosion. On the market, a stainless steel cylinder costs the price of three or four cast iron cylinders. They say that they are asked all the time to rehabilitate water points, to reinstall pumps that have not worked in a year and the reason is often because of rusty materials.

Another informant explained that he was contacted several times by the contractors who would often quietly say to him: "…*to help restart the pump, because there was not enough money in it* …". Basically, saying that the executed contract did not bring in enough profit for the service provider, one of the reasons they mentioned for not using the best quality materials.

Some key informants go on to say: "… *for a public contract of 4 million CFA francs, barely 1 million (2000 USD) is used for the construction of a well equipped with a motorized pump in some cases*… ». Given these statements, it was therefore difficult to know whether the malfunctions observed in the handpump functioning were due to the donors of the funds, to the contractors who execute the contract or to the objectivity of the inspections that precede the delivery of the contracts.

In addition, the experiences of the participants in the focus groups in the field indicate that the organizations that are committed to improving access to water in peri-urban and rural areas are not doing enough follow-up and monitoring in terms of the execution of these contracts. Moreover, the people who win these contracts do not always have the expertise in hydraulic engineering in terms of knowledge of the standards that should be used to execute the contract. A key informant stated: "…*we respond in a very short time to repair or rehabilitate 90 /100 boreholes that have been implemented in the field, sometimes only 3 months after putting the pump in operation* …".

6.3. Initiatives to prevent the rapid corrosion of handpumps

According to a key informant, pump corrosion was indeed the subject of informal discussions with his colleagues and he told them to complain that contractors were taking advantage of the public contracts they were awarded to "… *intoxicate the population*…". They thought that it was better to let the populations go back to their swamps like they did in the past, considering the very poor quality that the pumps provide, which is more like rusty water that poses a risk to the public health. To avoid this corrosion problem, some people have said that they have been using more and more stainless steel materials in handpump installation projects for some time now. As a result, they have called for greater awareness among stakeholders.

6.4. Reasons for the rapid handpump corrosion according to the population

In a group discussion, several mechanics stated that in their experience, pumps that are made of stainless steel do not rust at all, even if they are immersed in water, whether they are installed properly or not. According to many of them, this phenomenon of rapid corrosion of materials is mainly related to the quality of the material of which the equipment is made and not to the nature of the rock, or how long it has been since the pump was installed. They therefore think that handpumps made of poor quality materials do not last. « … *Barely 2 to 3 months after it is installed, the rust starts to attack so much that after 12 months the water comes out all red and rusty, when we are called in to repair it, the rod or the cylinder looks like a grain of corn attacked by weevils…* ". Not many key informants mentioned the reason for the aggressiveness of the water, also known as one of the determining factors for accelerated corrosion. Some people actually talked about the impact of the rock.

6.5. Repairing handpumps: A financial burden for populations that are already poor

A mechanic who has been a specialist in hydraulic infrastructures for 30 years says that he only intervenes for repairs if the population pays a significant amount, which varies around at least 100,000 CFA francs (about 200 USD) per intervention. The rates vary according to the type of malfunction and how far away the intervention sites are. The populations in certain localities have formed committees that collect money for repairs. Each household provides a mutually agreed amount that they contribute on a regular basis (e.g., every week, month, year). Sometimes they run out of funds due to numerous breakdowns and therefore frequent repairs. In that case, a Community Member can pre-finance them and be reimbursed later.

A long-time craftsman/mechanic who is often called in to repair handpumps also told us that he had abandoned the installation several times because of the population's lack of financial means. He also says that he makes financial proposals depending on the breakdown, the distance. In the meantime, the only solution for the population is to resort to other alternatives for water supply.

6.6. Experiences with pumps malfunctioning and challenges in terms of their maintenance in Cameroon

In the Foumbot area, the existence of a large number of pumps that were not functioning for various reasons were observed, including water that smells like rust in the Kounoure district.

ILLUSTRATION 1 : PUMPS ABANDONED A FEW MONTHS AFTER INSTALLATION.

Rainatou, a 38-year-old housewife, who has lived in the "*Petit Paris*" neighbourhood for a long time, was lucky enough to have a borehole drilled in front of her home in July 2021 by a charity organization. This neighbourhood owes its name to its proximity to the improved quality of housing here. This, however, is not the case for access to water or its quality. During the survey, this borehole had been down for 4 months (Illustration 1 in the middle), it only worked from July to August 2021. They say here that even when this water point was working, it barely gave 50 liters/day for a population of at least 700 people in this neighborhood. Moreover, the color of the water puzzled more than one person. The population here is ready to contribute to the rehabilitation of this water point despite the lack of initiatives. In the meantime, like the rest of the population, she has resorted to the public CAMWATER system, from which the neighboring house benefits and which flows sporadically (about 2 days/week), and mainly to a marsh located about 700 meters from her home, which flows continuously and for which she does not have to pay.

Illustration 1 on the left is a borehole with an handpump that is 5 years old. According to the population, the water that comes out of this pump has had a rusty smell and a reddish color since the installation of this pump in 2016. It had been out of commission for 8 months and was chained up when the study team passed by. No real initiative has been taken for its rehabilitation. It's the same for the borehole on the right.

ILLUSTRATION 2 : ALTERNATIVE SOURCES OF WATER SUPPLY WHEN THERE ARE NO FUNCTIONING PUMPS.

The testimonies of the population mention the abandonment of these water points for other alternative sources (traditional spring wells, marshes, etc.) as presented in *Illustration 2* or simply the nearby handpumps that work. Since CAMWATER is not available here.

The first image (Illustration 3 on the left) is a borehole equipped with a handpump provided by a charitable organization. Between March 2021 and December 2021 (at the time of the study visit) there were three (03) breakdowns. respectively due to a broken chain and a loose bolt on the inside of the device, because children had been abusing the pump. The only drawback here is the water, which she said was "*a little salty*". However, people prefer it over spring water. When the study team passed by, it was blocked with a padlock, which is why these children who were looking for water were waiting. It must be said that it was in order to avoid abuse of the structure that this was put in place.

ILLUSTRATION 3 : CHILDREN LINE UP IN FRONT OF A PUMP THAT IS BARELY RUNNING DUE TO A LACK OF MAINTENANCE.

In fact, they leave the pump open from 8am-10am and 4pm-7pm depending on the number of people around the water point. In the event of a breakdown, any kind-hearted soul in the neighborhood can help out and be reimbursed for the costs they have incurred. The cost of repairs incurred during the last breakdown was around 75,000 CFA francs (150 USD). Each household usually contributes up to 200, 500 or 1000 CFA francs depending on the breakdown.

The next borehole (Illustration 3 on the right) is three years old. The problems encountered are respectively:

- The influx of the population around the water point. The enormous need for water.
- Recurring breakdowns and maintenance problems. In the event of a breakdown, the population has to contribute. Each household has to contribute 1000 FCFA/year. The last breakdown dates back to September 2021 (3 months before our visit). At times, people were reluctant to pay these contributions because of the endemic poverty here.
- There are no regulations for the work of these mechanics, so there is no standard price and everyone charges a different rate.

In the Announcement Bulletin of April 2022 published by the Public Contracts Regulatory Agency (ARMP) mentioned eighteen (18) handpumps compared to three (03) solar water pump systems. This suggests an ever-increasing demand for handpumps (Image on the left, Illustration 4) despite the corrosion phenomenon, multiple breakdowns and maintenance concerns (Image on the right, Illustration 4).

ILLUSTRATION 4 : EXAMPLE OF THE EVER-INCREASING NUMBER OF HANDPUMPS IN CAMEROON AND THE MAINTENANCE CONCERNS.

7. Conclusion

In Cameroon, the phenomenon of rapid corrosion of boreholes equipped with handpumps is a reality that can be observed in peri-urban and rural areas, despite the scarcity of literature on the naturally high pH-level and iron content of the groundwater, which has been proven to be a key determining factor in other parts of Africa.

The actors involved in financing of handpumps in Cameroon are mainly government projects, development partners. Some individuals from peri-urban and rural areas that are not serviced by the public CAMWATER system. The installation of this infrastructure is done by private companies. Just like their maintenance for which there is more use of volunteer mechanics, most of whom are trained informally to repair the pumps.

The most common brand of pump that is sold by hardware stores and installed in these areas is the India Mark II, imported mainly from India, China and neighboring Nigeria.

There is no specific documentation of standards for the quality of materials that should be imported or recommended for use in installing handpumps in Cameroon. This lack of regulation along with a weak "quality" control of the structures before their delivery by the contracting companies would play a significant role in the quality of the materials being used. However, it is important to remember the donors, in cases where the funds that were raised for these projects to install handpumps are not substantial.

Discussions with people in these communities indicate multiple breakdowns and high maintenance costs for these often already mostly poor populations. They also complain about the lack of systematic and regular maintenance of these hydraulic infrastructures after they have been installed. This would cause the communities to reject many of the water points. In some cases, this rejection of water points is aggravated by the phenomenon of the corrosion of pump materials, which is a major global problem that the WASH sector has not fully grasped yet, and which may prevent the achievement of Sustainable Development Goal 6 in Cameroon. As a result, local populations as well as stakeholders in the industry are calling for more sustainable solutions considering the public health threats many WASH systems (e.g., hospitals, schools, households) in rural areas are facing.

8. Recommendations and perspectives

In order to solve this problem in Cameroon, this study recommends:

- Mapping the 10 regions of Cameroon at high risk of handpump corrosion based on the pH levels and natural iron content of the groundwater. It implies that a more comprehensive study could be conducted, taking the biological and physicochemical parameters of the rock and their contribution in the rapid corrosion of the materials into account. Danert (2022a) concluded that if components made of inappropriate materials are installed in "aggressive" groundwater (i.e., water with a low pH and therefore acidic), they will corrode rapidly. As a result, the life of a pump is considerably shortened if galvanized iron (GI) pump rods and riser pipes are installed in water with a pH below 6.5.
- Specifying the norms and standards that apply to the quality of materials that can be imported and sold by local suppliers of handpump materials. These standards must also reflect the WHO guidelines for water quality (GDWQ) in addition to those further specified by ANOR in this sector. Therefore, once these standards and responsibilities have been established, the government would be well advised to ensure that these standards are respected by the players in this market, and even to reinforce the capacity of local contractors in this field so that they can make a selective choice of materials and improve the execution of pump installation contracts.
- Creating a database and/or a map of existing handpumps based on whether they are functioning or not. Especially for those in healthcare facilities and schools, considering the large number of handpumps that are installed there in Cameroon.
- Encouraging the use and appropriation of innovative technologies by municipalities and local operators to monitor the functionality of hydraulic infrastructures such as HPs, including remote monitoring devices (RMS).
- Setting up maintenance operations for handpumps and providing them with the necessary resources to ensure the continuity and sustainability of their services. By incorporating optimal and participatory management models that involve CBOs and municipalities, including strengthening their capacities as needed.

- Undertaking another study focused on an overview of the functionality flaws of handpumps in institutional WASH systems (hospitals and schools) in Cameroon and the implications for these settings in terms of the SDG-6.
- The popularization of solar panel boreholes as an alternative in rural and peri-urban areas of Cameroon would be welcome, given their long-term performance and the costs associated with their maintenance would be compatible with the resources of low-income populations.
- The government must make its development partners and financial partners aware of the risks of handpump corrosion in areas with a low pH level and take them into account in their multi-sectoral strategic planning.

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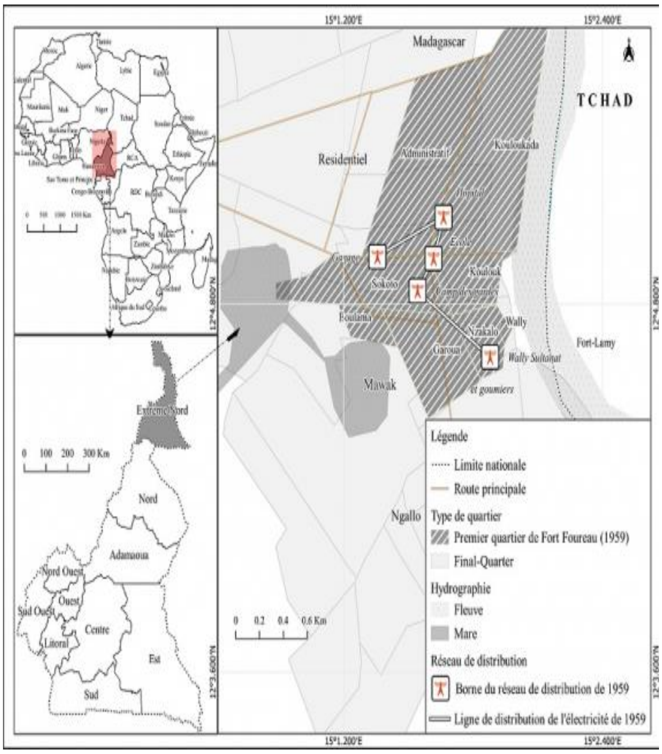
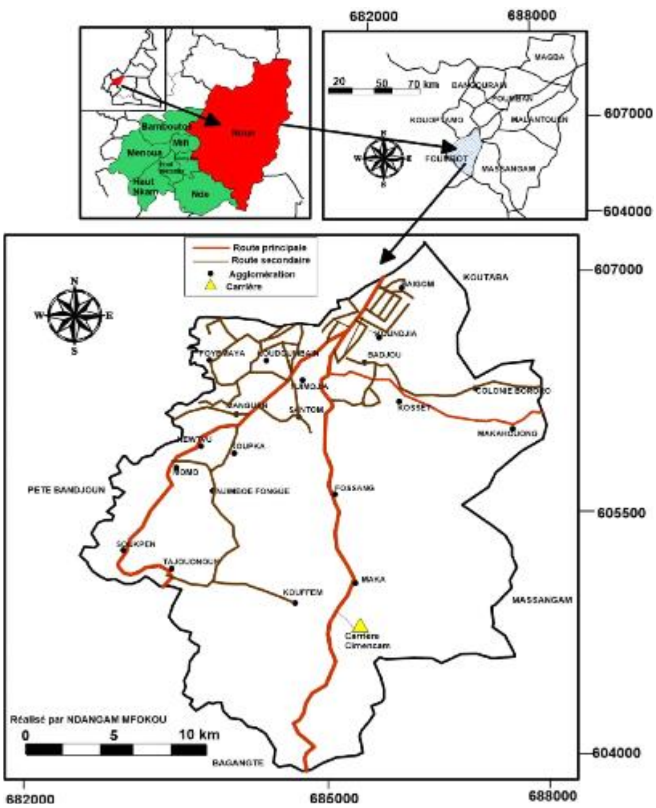
Appendix 1: Maps of study sites

Kousseri area (Far North Region, Cameroon)



Foumbot area (Western Region, Cameroon)



Appendix 2: Interview guides for key informants

TARGET: CRAFTSMEN/MECHANICS

1. To what extent are handpumps used in the community and for what reasons? *(Explore reasons compared to other sources of drinking water supply)*
2. What are the most common brands of hand pumps in this locality, based on a sample of 10 pumps at the site? *(Afridev, India Mark II, India Mark III, Vergnet Hydro HPV, Rope Pump, Blue Pump, Life Pump,...)*
3. Which brands do you repair the most?
4. What are your specific concerns about handpumps?
5. Which spare parts do you deal with the most when repairing pumps in the areas where you work?
6. What problems and defects are you aware of regarding spare parts for pumps?
7. Are you aware of rapid pump corrosion problems in the areas where you work?
8. How would you describe this rapid corrosion problem where you experience them? (*Explore with 10 samples of pumps, the effect of the time you spend on the pump/borehole, the connection to the climate, the quality of the soil, the pump brands, the age of the pump, others...*)
9. How do you describe the impact of this corrosion problem on the functionality of the pumps where these problems occur? (*Explore with 10 samples of pumps the frequency of functionality per week/month, other...*)
10. How would you describe the impact of using pump water by the population where these corrosion problems are experienced? (*Explore with 10 samples of pumps the reluctance due to the water quality, the rusty smell, other things...*)

TARGET: THE PEOPLE THAT USE THE PUMPS

1. To what extent are handpumps used in the community and for what reasons? *(Explore reasons compared to other sources of drinking water supply)*
2. From which organization(s) do you benefit from this (these) handpump structures? (*Explore with a sample of 10 pumps how many are donations, from which organizations, from the government or from individuals' own funds*)
3. What are your specific concerns about handpumps?
4. What are the problems that regularly cause water points/boreholes equipped with handpumps to stop functioning or function poorly in this locality?
5. Are you aware of any pump corrosion problems in this area?
6. How would you describe this pump corrosion problem where you experience them? (*Explore with 10 samples of pumps, the effect of the time you spend on the pump/borehole, the connection to the climate, the quality of the soil, the pump brands, the age of the pump, others...*)
7. How do you describe the impact of this corrosion problem on the functionality of the pumps where these problems occur? (*Explore with 10 samples of pumps the frequency of functionality per week/month, repair costs, other things...*)
8. How would you describe the impact of using pump water by the population where these corrosion problems are experienced? (*Explore with a sample of 10 pumps the reluctance due to the quality of the water, the rusty smell, the occurrence of diseases, the financial costs associated with the pumps not working, the reliability and acceptance of other things...*)
9. What alternative solutions for drinking water supply have you implemented here as a result of the pump(s) being shut down where these corrosion problems are being experienced?