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What cost a forgotten History? Implications of Groundwater Quality on Hand Pump Standardisation in Uganda

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Abstract

In recent years there has been an increasing awareness, amongst sector actors, of handpump corrosion and iron contamination issues across Uganda. Since 2014, GOAL has been collaborating with other actors to establish the scale of the corrosion and iron issue across the country. Much of the formative research in this field was conducted as early as the late 1980s when research and field experience clearly showed that galvanised iron (GI) was not suitable for installation in aggressive groundwaters ($pH<6.5$). Using this as a benchmark together with data from the Directorate of Water Development, GOAL was able to confirm that approximately 30% of all groundwater was aggressive and not suitable for the installation of GI materials – as per the National Standard for handpump selection. This finding poses a number of issues for the government and implementation partners. The issues together with possible responses and consequences are presented in this paper.

Introduction

Approximately 82% (28.4 million) of Ugandan population is classed as rural. The vast majority rely on hand pumps to access to their daily water supply. The Government of Uganda (GoU) 2015 Sector Performance Report states that of the rural population with access to improved water (currently just 65%) nearly 66% rely on boreholes and shallow wells, which implies that some 12.2 million people are reliant on hand pumps on a daily basis.

Functionality of rural water points across Sub Saharan Africa has been reported by others[1] to be in the region of 65%. In Uganda the level of functionality reported by the government is somewhat better than this and as of 2015 Sector Performance Report stood at 88% (varying across districts from 58% to 98%) - though the true figure is likely to be less than this as this figure includes functioning boreholes that have been abandoned (presumably due to poor water quality).

Non functionality due to technical breakdown is reported as the most common cause of failure. Whereas these can be caused by multiple types of failure, corrosion appears to be one major cause. Corrosion of handpump parts is important as it can lead to pump abandonment in a number of ways:

1. Corrosion can cause technical breakdown of the pump which is beyond the capacity or financial means of the community to repair.
2. Corrosion can result in high iron in the water leading to taste issues and discolouration of food and laundry.
3. Corrosion leads to a repeated rapid corrosion and replacement cycle which eventually wears down the resolve of the water committee and community to keep replacing parts.

As early as the mid-1980s research was being undertaken as part of the World Bank Handpumps Project, which analysed groundwater quality and handpump corrosion in the West African sub region. In 1987

[1] RWSN (2009) *Handpump Data 2009.*

Otto Langenegger first published his findings from the rigorous laboratory and field research of the project that had been undertaken across five countries in West Africa. The complete findings were later published in the synthesis works of 1994[2]. In these papers Langenegger makes some very critical statements which should have had a significant impact on the selection of hand pump materials but seem to have been forgotten over time.

Langenegger reported that despite corrosion being a highly complex process that was difficult to predict with any level of confidence, groundwater pH did appear to offer some guidance as a corrosion index – particularly with regard to galvanised iron pump rods and riser pipes.

He determined that in moderately aggressive groundwater (pH<6.5) the zinc coating is stripped off in a matter of months. Figure 1 below is taken from Langenegger and shows concentration of zinc and iron over a year in 2 boreholes with aggressive ground water.

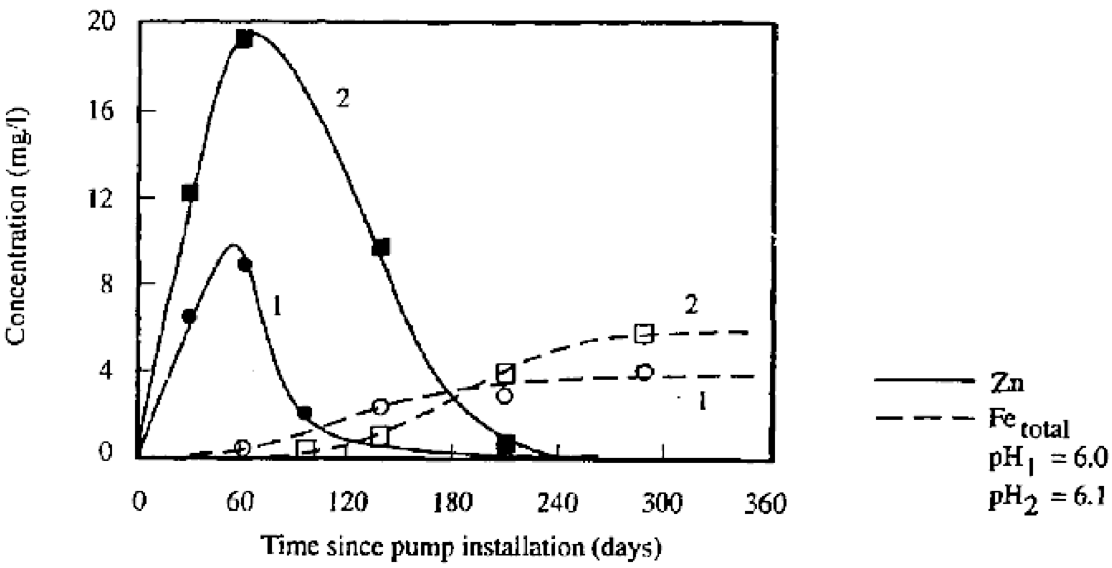

Figure 1. Zinc (Zn) and total iron (Fe_{total}) concentrations in groundwater versus time since installation of two non-corrosion-resistant handpumps (Moyno with galvanized rising mains and pump rods; Cote d'Ivoire). The iron concentration increases after the zinc peaks; that is, as soon as the protective coating (galvanization) is no longer intact.

The significance of this is that for aggressive groundwaters (pH<6.5) the quality of the galvanising has little to no impact on protection from corrosion. In the tests above the GI pipes were of high quality conforming to ANSI standards.

Independently, at a similar period in Uganda, the RUWASA project was learning from its own large scale hand pump installation project which was being implemented in the East of Uganda. The RUWASA (Phase I) project ran from 1991 until 1996 and was funded by DANIDA to the tune of $35,000,000[3]. During the initial phases of installation, community feedback brought their attention to the severe corrosion issues experienced in the new installations. Within 19 months of starting, the project switched

[2] Otto Langenegger 1994; *Groundwater Quality and Handpump Corrosion in Africa*
[3] N. Asingwiins, D. Muhangi, July 1997, An Analysts of the Impact of Institutional Rules on Rural Water Sustainabtlity. Uganda Country Report

from GI to stainless steel. The programme switched initially to 304SS but a year later to 316SS which has greater resistance to corrosion[4].

Handpump Standardisation

Around the same time, many Sub-Saharan countries had been grappling with the issue of handpump standardisation. Some opted for full formalised standards (such as Uganda) and others preferring to use less binding and more flexible approaches such as recommendations or endorsements. Although there are pros and cons for each of these approaches, it is clear that the intention of hand pump standards was to limit the number of different models used in a country, thereby simplifying supply chains and making it easier and more affordable to access pumps, spares and supplies for the rural communities. Whilst at the time there was widespread support for standardisation from the sector, there has also been increasing concern, more recently, leading to a largely polarised view on the benefits and constraints caused by pump standardisation. Apprehensions around standardisation include: monopolisation of the market; stifling of innovative and low cost technologies; lack of incentive to improve the quality of pumps; and possible unsuitable technology selections[5].

Despite the evidence being published at the time, the government of Uganda decided on a hand pump standardisation strategy based on the India MkII and Mk III hand pumps (referred to as the U2 and U3 in Uganda) with GI riser pipes and connecting rods. The Standard was formally adopted in 1999.

In the Uganda standards provision is made for corrosion resistant materials (stainless steel) in the U2/U3 pumps, however the criteria for triggering their use (pH<5.5) are significantly lower than the recommendations of Langenegger or what experience from the field would suggest was appropriate. The following table shows the criteria for material selection as stated in the standard:

Water Quality	Connecting Rods	Riser Pipes	Cylinder
- pH value 5.5 or more - Oxygen level 2mg/ltr or less	Galvanised Mild Steel (GI)	Galvanised Mild Steel (GI)	Cast Iron with Brass Liner
- pH value 5.5 or **Less** - Chloride level up to 200mg/ltr	Stainless Steel AISI 304	Stainless Steel AISI 305	Cast Iron with Brass Liner or SS AISI 304
- pH value 5.5 or **Less** - Chloride level up to 200mg/ltr	Stainless Steel AISI 316	Stainless Steel AISI 316	Cast Iron with Brass Liner or SS AISI 316

Table 1. Hand Pump Material Selection for Different Water Qualities (Extract from Annex B to the Shallow Wells Handpump (U2/U3) Standard Specification, 1995)

Subsequent to the original standards there were additional modifications of the U3 to further address the corrosion issues by introducing corrosion resistant materials and creating the U3M (M= modified).

In the years that followed the government and organisations continued installing the U2 and to a much lesser extent, the U3 and U3M – in accordance with the government standards. As emphasis for much of the intervening years was largely on access rather than maintenance, the corrosion issues seem to have been largely forgotten.

Corrosion issues re-surface 20 years later

GOAL Uganda has been working in the south east of Uganda since 2011. In 2014 a new water access project commenced working to increase water access in four sub-counties of two districts (installing new

[4] *Baumann 1998, Handpump Technology Input to the Joint Review of the Rural Water Supply and Sanitation Eastern Uganda Project-RUWASA Phase IIA*
[5] Jess MacArthur, 2015; Handpump Standardisation in Sub-Saharan Africa.

boreholes with the India MkII - in accordance with the national standards). During routine monitoring in one of the districts the following year, communities started to complain of iron issues and corroded pipes.

Surprised at the speed of corrosion, GOAL started an investigation as to the cause. A review of the pH of the groundwater at 44 new boreholes indicated that approximately 65% were installed in aggressive ground waters (pH<6.5).

GOAL Uganda leads an informal Rural Water Supply O&M Practitioner's Forum which meets quarterly in Kampala. The issues of corrosion and Iron were shared at the forum and clearly had much resonance with participants. Several organisations agreed to share their own data for analysis, in an effort to establish the scale of the issue in Uganda. Anecdotally it seemed as though the problem was widespread – but what was really needed was hard evidence to enable the scale of the issue to be understood and to guide future discussion with the government. Data from other organisations was collected and analysed for pH. It showed that the proportion of boreholes sited in aggressive ground water was around 34% (from 800 data points).

Although this data did indeed indicate that there may be a significant corrosion risk across the country, the data sources available[6] were still clustered in small areas and did not cover the whole country. A request to the Directorate of Water Development (DWD) resulted in access to the water quality database used to develop ground water quality maps for various districts within the country. Some 29,000 data sets were shared in total, but these included both surface as well as ground water sources. After filtering the data for boreholes and shallow wells together with pH data, some 8200 data sets remained. Although not every district was represented the data still provided significant coverage across the country as can be seen in the figure below:

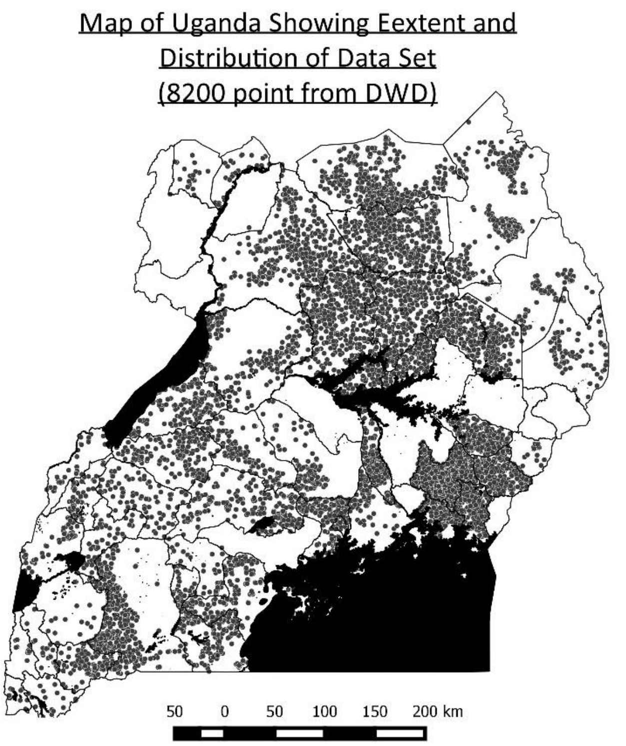

Figure 2 Map showing Extent and Distribution of the DWD Data set.

6 T… ollected through their own research or m… ıst data that was available at the time of the investigation.

Analysis of this water quality data showed that approximately 30% of all Borehole and Shallow well water sources have a pH less than 6.5.

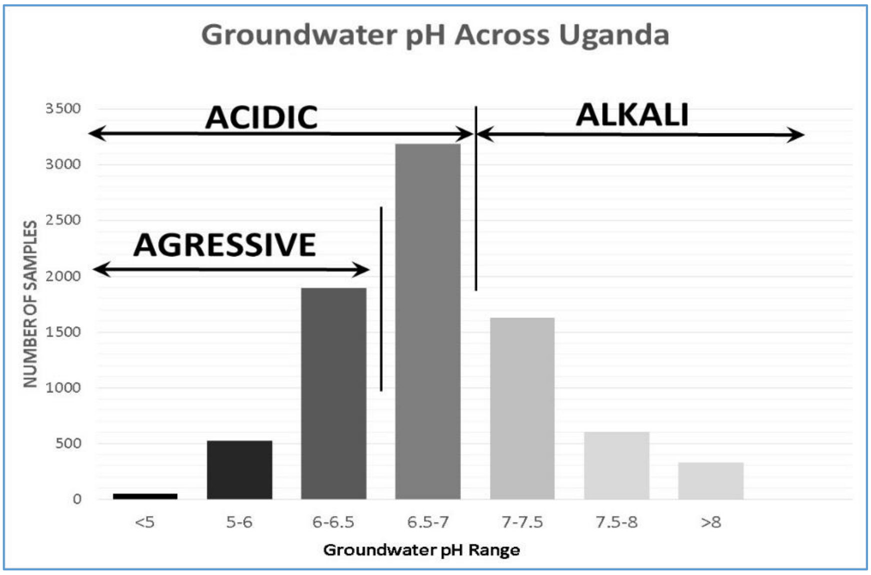

Figure 3. Distribution of Groundwater samples by pH Range

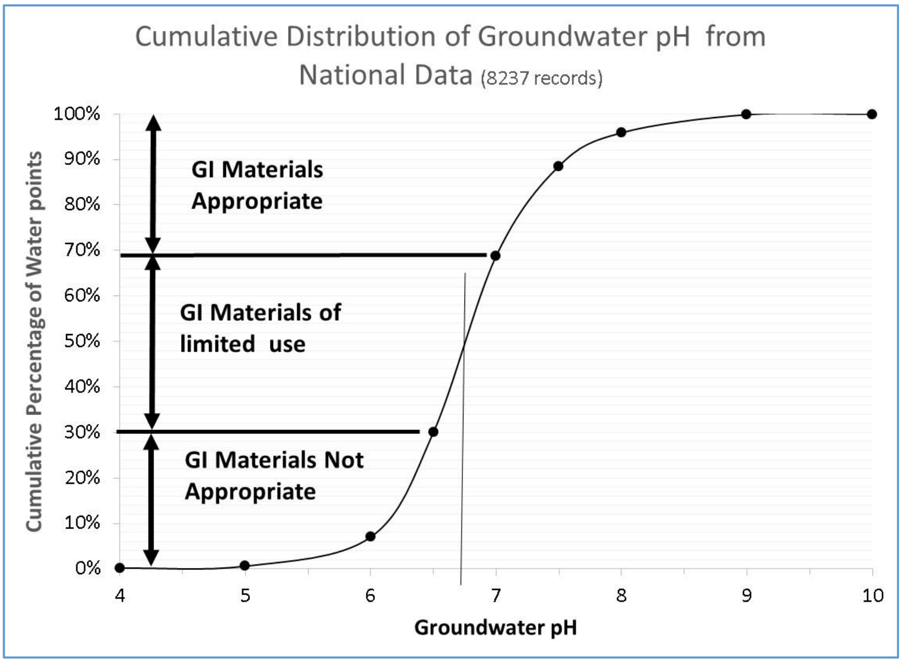

Figure 4. Cumulative distribution by Water point pH

Given that there are almost 25,000 handpumps in Uganda, this implies that some 7,500 hand pumps are installed into aggressive ground water; GOAL staff have seen high-levels of compliance with the national U2 (India Mark II) around the country and this implies that the vast majority of these pumps will be using unsuitable GI pipe and risers.

Some stakeholders have cast doubt on the reliability of the water quality records that are logged with new boreholes[7]. This stems largely from the fact that it is generally the responsibility of the driller to collect and deliver samples to the government laboratories. As there is no control over the process there would seem to be significant opportunity for standard procedures to be ignored. In order to test this hypothesis, GOAL performed an independent analysis of the 44 boreholes reviewed earlier. The results shown in figure 5 below show a very close correlation to the original data submitted with the borehole logs from 3 different contractors. Clearly this is a tiny sample and other drillers may (or may not) follow their own procedures which could result in erroneous data, however this result does offer some confidence that not all of the data can be discounted.

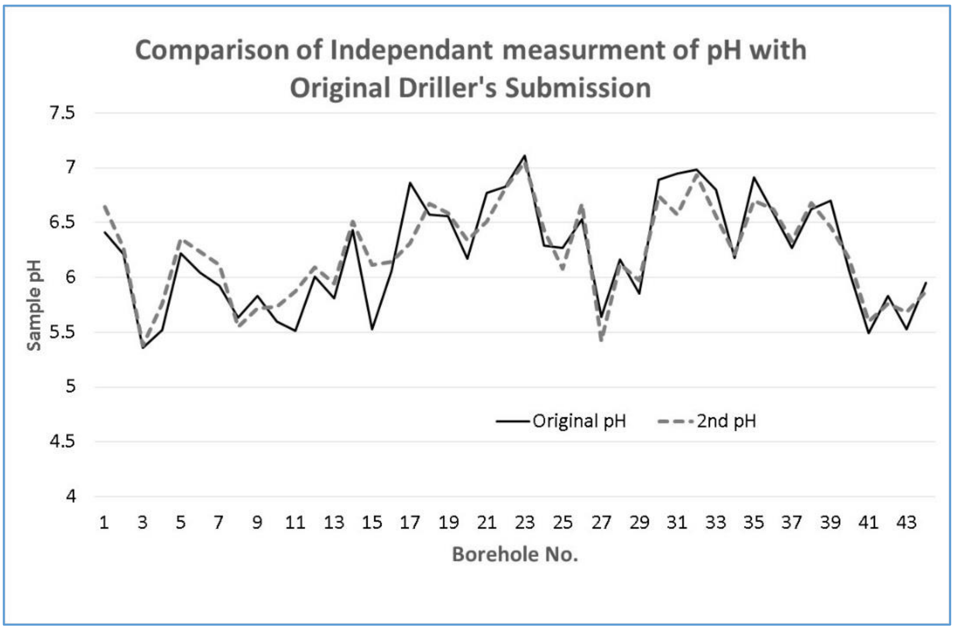

Figure 5. Independent Verification of the Original Water Quality Data Submitted by Drillers

Conclusions

Given the evidence and recommendations from Langenegger and the RUWASA Project together with more recent in country research (V.Casey et Al, 2016; WE Consult, 2016), then this data clearly shows that there is a significant issue in Uganda with regards to risk of corrosion that the current handpump standards fail to address adequately.

The original intention of introducing the Handpump Standardisation strategy would appear to have been a sound approach that achieved its objective. However, the standard developed for Uganda is not appropriate for the India Mk II hand pump in all areas. As a result there is likely to be an increased financial burden being placed on the 30% of rural communities that are unfortunate enough to rely low pH ground water for their domestic needs. In turn this will contribute to lower functionality levels across the country given the general lack of capacity of the community to deal with repeated corrosion based repairs.

This is exactly the issue the J. MacArthur was referring to in the conclusions to her paper when she says:

"Some formal standardisations need a facelift. While many formal policies started out with good intentions, a lot has changed since the 1990s and some policies need to be revised due to improper selections or limitations on the incorporation of improved

[7] V Casey et al, 2016; The role of handpump corrosion in the contamination and failure of rural water supplies

technologies. This is a lengthy and costly process, which requires the collaboration of many handpump stakeholders on both the local and global levels. Additionally, while standardisation is controlling the installations across the continent, the topic has lost momentum in the global sustainability dialogue."

Clearly switching to non-corrosive materials is not a simple exercise as there are several factors that need to be considered. Firstly there is the issue of supply chains – or lack thereof – that will need to be established. Secondly there is the issue of training technicians to become familiar with the different materials and thirdly there is the extra funding that will be needed to pay for the corrosion resistant materials – especially stainless steel.

Whilst this discussion has focused on the situation in Uganda, the problem is certainly not isolated. Given that many of the standards that are still in place across the continent were written more than 25 years ago and how our knowledge and available technology has developed in that same period it is highly likely that the existing standards are no longer the most appropriate. However, having struggled to get standards in place, many governments seem to be happy to continue using them even when there may be clear need to update or adapt them to better suit the situation on the ground. In part this seems to be caused by aspirations to provide a higher level of service altogether (small piped networks) which are becoming more viable as technology improves. Welcome though a higher service level maybe, it is unlikely to effect the majority of the existing handpump users for decades to come.

The India MkII is the most commonly used hand pump across sub-Saharan Africa[5], currently used in 25 countries out of the 35 that use handpumps. There are potentially lessons to be shared and learnt from other country's experiences. In Uganda the India Mk II (U2) has far wider use than the U3 and U3M. In part this is down to a lack of familiarity with these pumps among the sector actors and mechanics, but also it is only suitable for depths of up to 45 m which is insufficient for many locations. Furthermore as the U3M uses large diameter PVC pipe, which is not currently widely available and quality is a constant issue leading to frequent breakages – further weakening its image in the sector.

Recommendations

1. At the national level, raise the issue of handpump corrosion and the inadequacy of the current standards for the prevailing groundwater conditions with the government and partners.
2. In the short term a relatively simple step would be to raise the limit at which pH triggers the use of corrosion resistant materials – from 5.5 to a minimum of 6.5 and preferably 7.0.
3. Work together with the government and sector partners to establish more appropriate handpump standardisation strategy (is the India MkII still the most appropriate pump for Uganda?).
4. Agree interim and longer term plans to address the issue of pump corrosion – firstly for new boreholes, and then for the replacement or upgrade of corroded pumps.
5. Use the complete water quality database (each borehole has water quality test conducted that is logged with the Ministry of Water and the Environment) to produce a complete Groundwater pH map that could be used to raise awareness of potential hotspot areas and the corrosion issue in general.
6. Verify the validity of the above pH analysis and data by independent pH measurement on a significant number of data points.