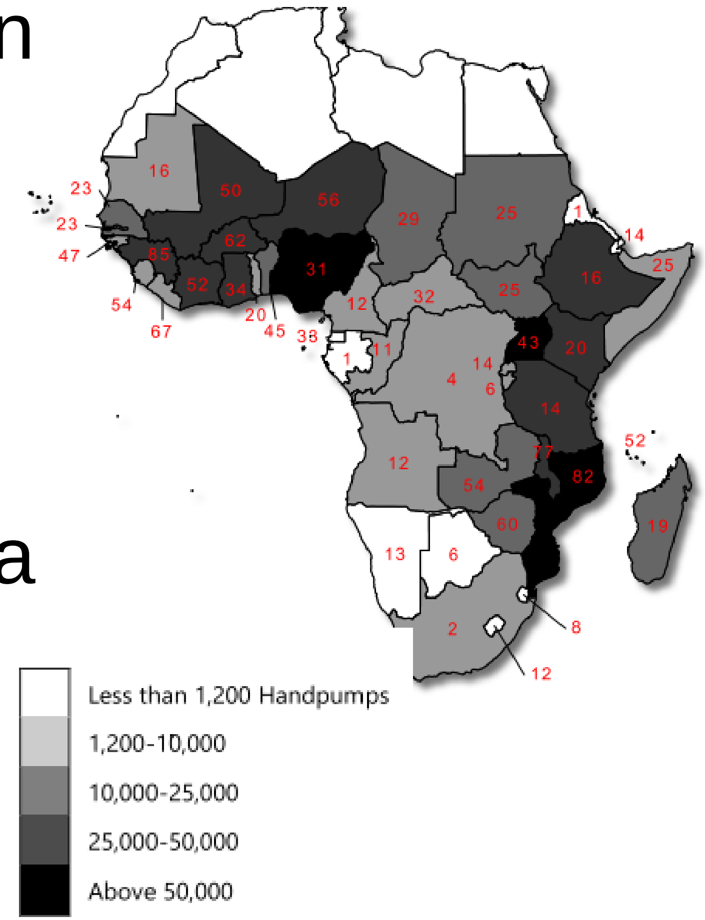
New Signs of an old Problem:

High Iron Concentrations, Corrosion of Handpump Components in Aggressive Groundwater, and Lessons From WaterAid's Recent Experiences in Uganda

Authors: **Vincent Casey** (WaterAid), **Lawrence Brown** (Hafren Water), **Jake Carpenter** (Independent) - Presenter

Scope of Handpumps

- ~184 million people relying on handpumps in SSA[1]
- ~1 million handpumps installed in SSA and 60,000+ installed each year[1]
- >4 million handpumps in India



Source: MacAurthor (2015)[1]

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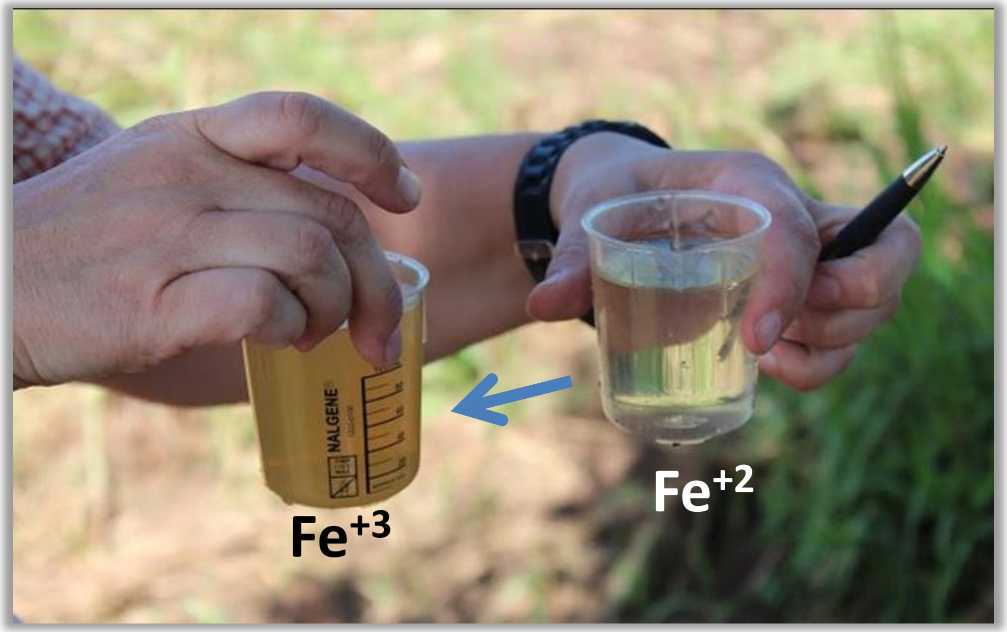
High Iron Concentrations

- WHO advisory[2]: 0.3 mg/L
- Uganda Limit: 1 mg/L
- Symptoms
  - Brown/red water
  - Iron/metal taste and smell (often described to be similar to blood)
  - Stains food / clothes when cooking / washing



Color change after 30 minutes

High iron is undesirable to users and can result in water point abandonment – users switch to traditional sources that were, often surface water (Health Risks!!!)

Sources of iron in handpump wells

Natural

Iron present in groundwater from soils/rocks in aquifer

Corrosion

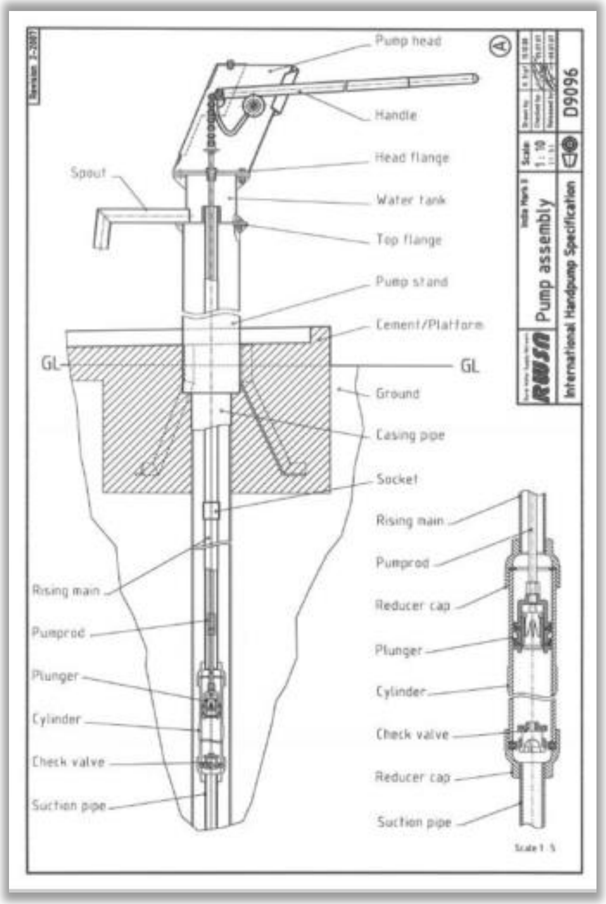
Iron from susceptible* handpump components

Aggressive GW = pH < 7

Iron in handpump water supplies

*Galvanized steel (GI) is a very common material for handpump components and is susceptible to corrosion when used in wells with aggressive groundwater.

Susceptible downhole components



Galvanized (GI) Materials:

Rising Mains
(aka Riser Pipes)

Pump Rods
(aka Connecting Rods)

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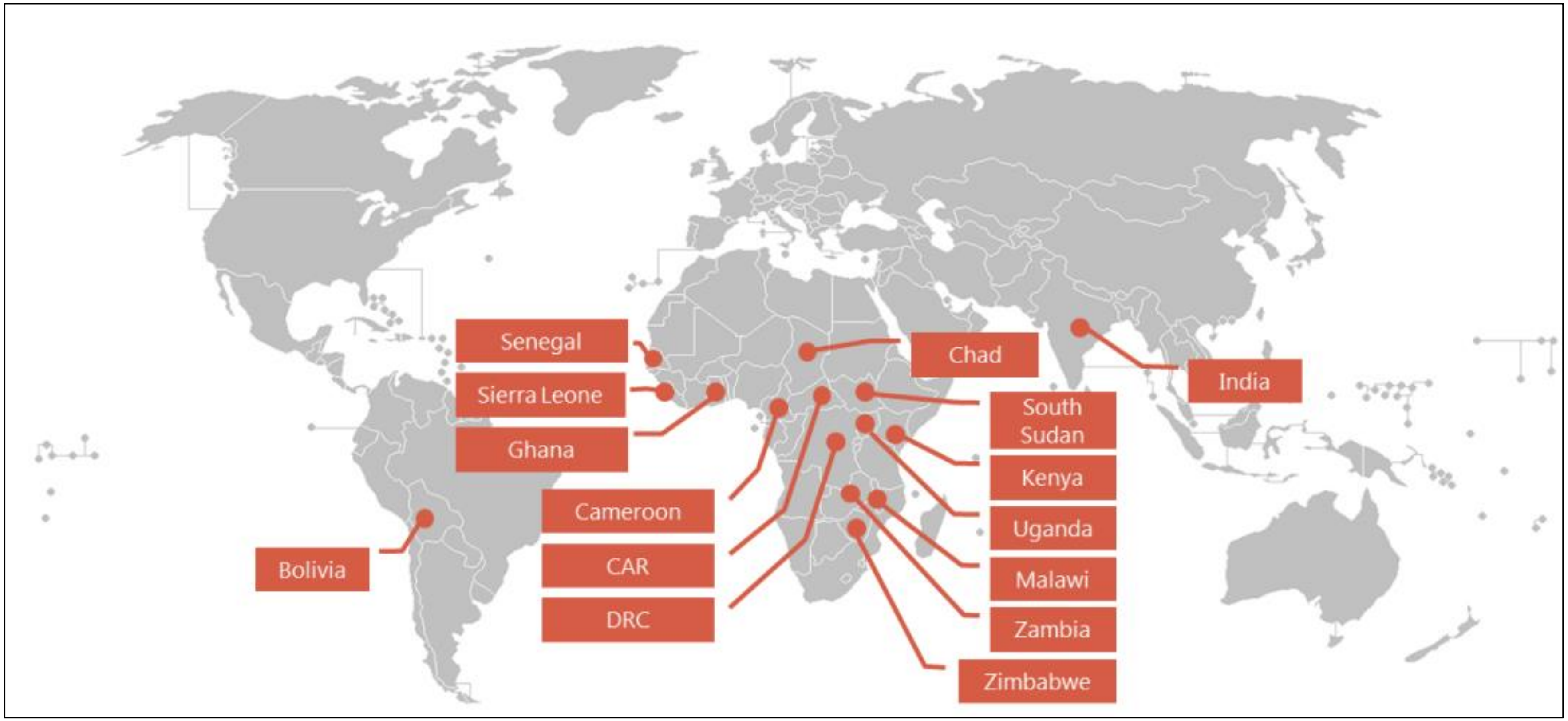
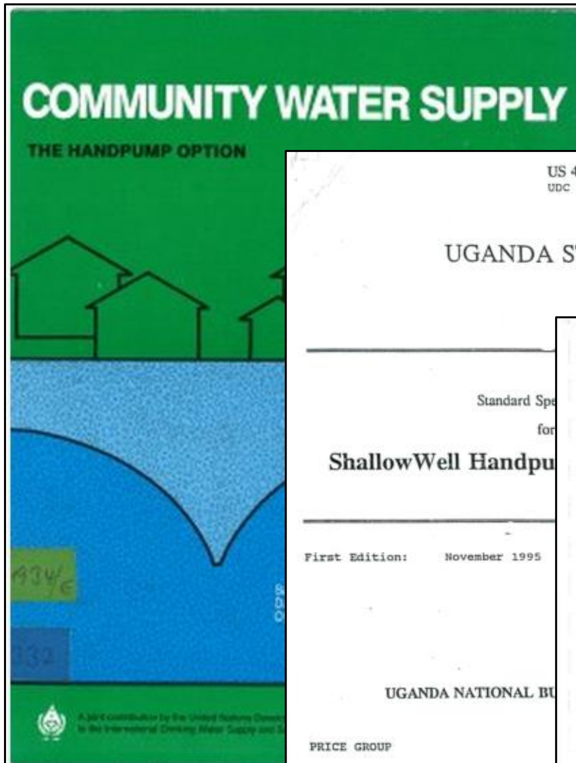
Recent reports of iron / corrosion problems



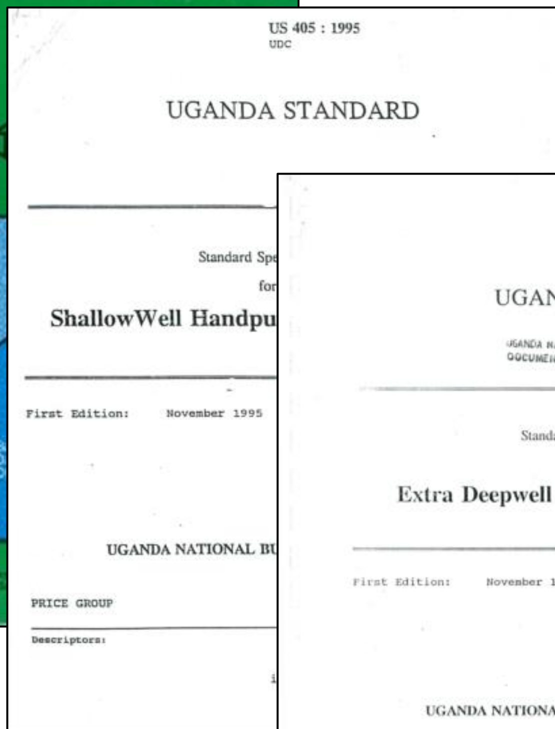
It is very likely that there are currently iron /corrosion problems in many other countries

Source: Furey, S. 2014. *Handpumps: where now? - A synthesis of online discussions (2012-2014)*. Rural Water Supply Network/SKAT Foundation. St. Gallen, Switzerland. www.rural-water-supply.net/en/resources/details/614

Literature on handpump corrosion



1987


US 405 : 1995
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UGANDA STANDARD

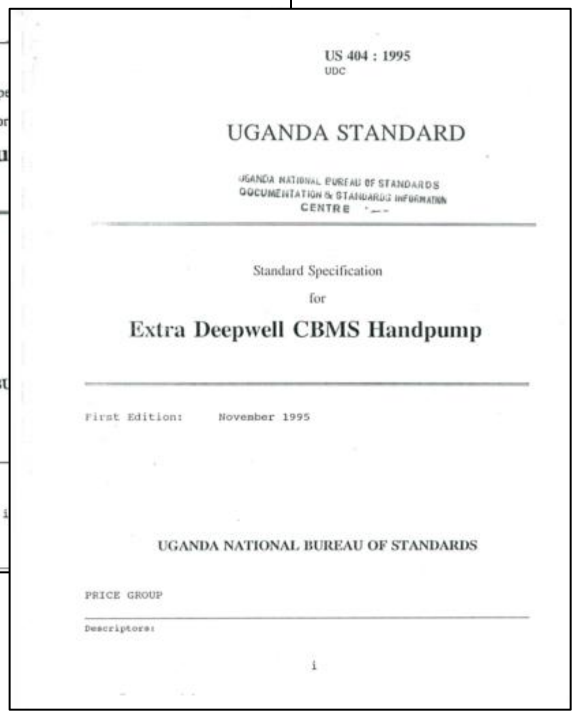
Standard Spe
for
ShallowWell Handpu

First Edition: November 1995

UGANDA NATIONAL BU

PRICE GROUP

Descriptors: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UDC

UGANDA STANDARD

UGANDA NATIONAL BUREAU OF STANDARDS
DOCUMENTATION & STANDARDS INFORMATION
CENTRE

Standard Specification
for
Extra Deepwell CBMS Handpump

First Edition: November 1995

UGANDA NATIONAL BUREAU OF STANDARDS

PRICE GROUP

Descriptors:

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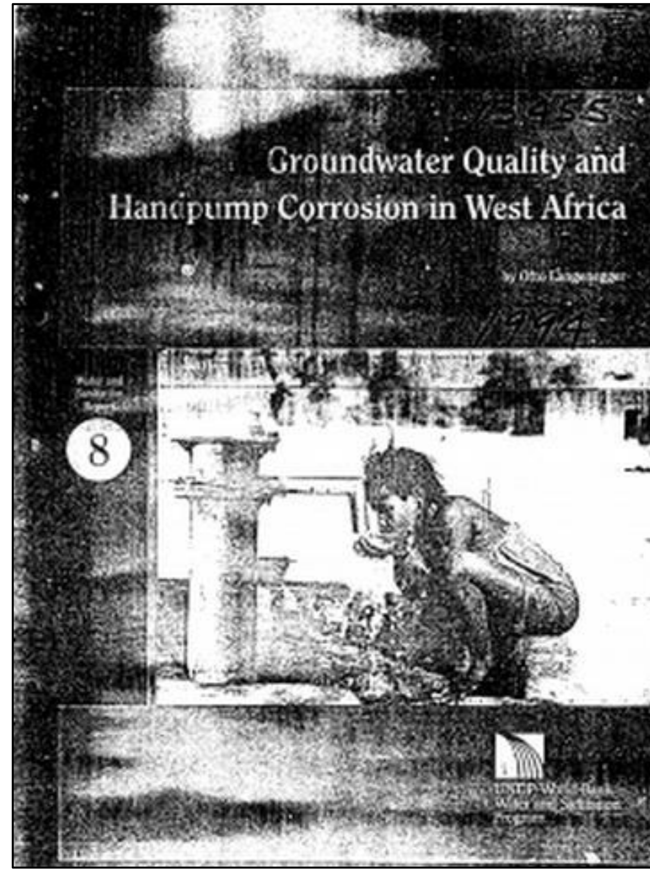


1994

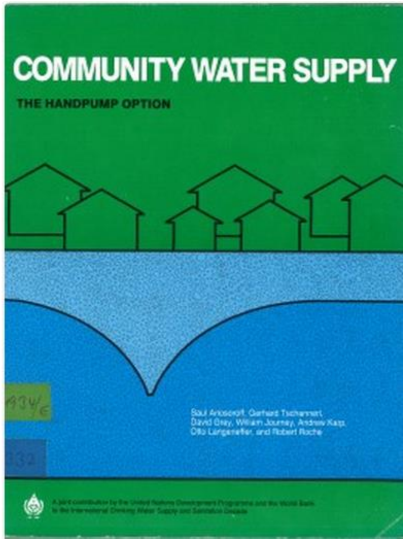
Literature on handpump corrosion

1981-1986 : "The World Bank / UNDP Handpumps Project"

THE WORLD BANK

UNDP

- 2,700 handpumps (of 76 types) in 17 countries, 5 years
- *Community Water Supply: The Handpump Option*[4]



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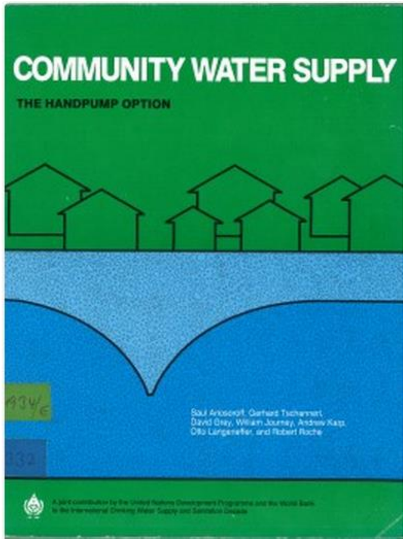
- PVC, ABS, stainless steel, are common materials for corrosion-resistant components



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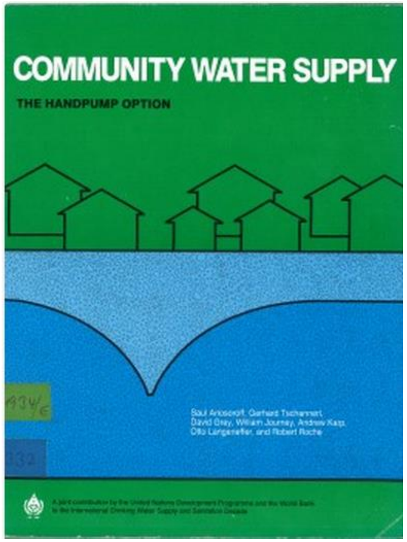

"Corrosive groundwater is much more widespread and much more damaging than previously suspected, in both Africa and Asia."

Literature on handpump corrosion

The Impact of Handpump Corrosion on Water Quality (1987)[5]

- Corrosion causes high iron and leads to pump breakdowns
- Pumping test method to identify the source of iron in pumped groundwater

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THE WORLD BANK

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- Corrosion causes high iron and leads to pump breakdowns
- Pumping test method to identify the source of iron in pumped groundwater

"Corrosion is the main cause of the iron problem with handpump-equipped wells in West Africa and probably in many other parts of the World."

Literature on handpump corrosion

66% of handpump breakdowns attributable to corrosion

"…in the 3000 Well Drilling Programme in Southern and Central Ghana, it has been found that 2/3 of the handpump breakdowns were directly or indirectly attributable to corrosion"

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30% of handpumps rarely used because of iron from corrosion

"Field experience suggests that up to 30% of handpump equipped water points are very little or not used mainly due to corrosion related water quality problems."

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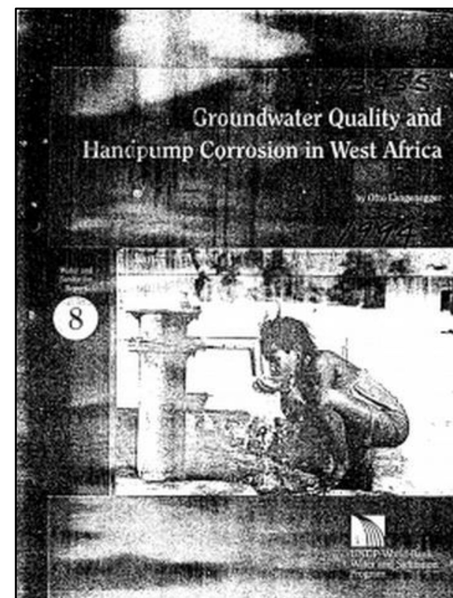
"Field experience suggests that up to 30% of handpump equipped water points are very little or not used mainly due to corrosion related water quality problems."

"it becomes more and more evident that the corrosion problem with handpumps is not only restricted to West Africa [where the research took place] but occurs all over the world."

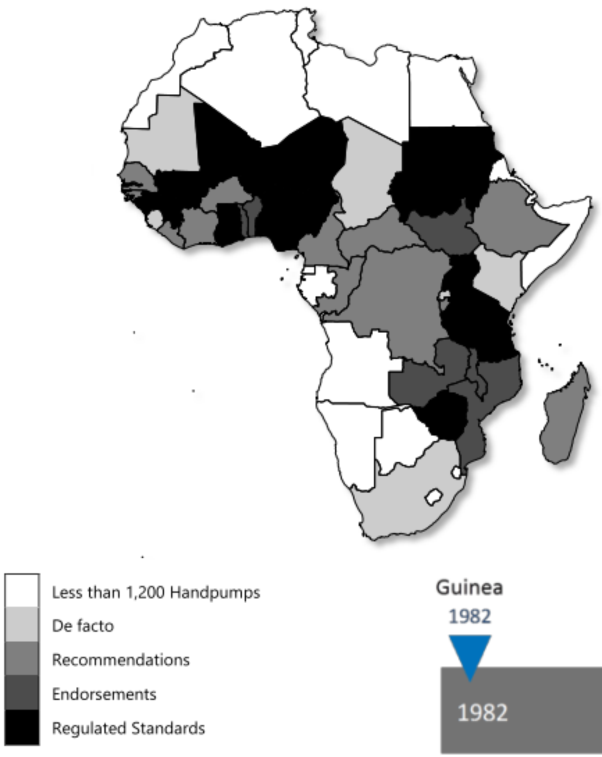
Literature on handpump corrosion

Groundwater Quality and Handpump Corrosion in West Africa (1994)[7]

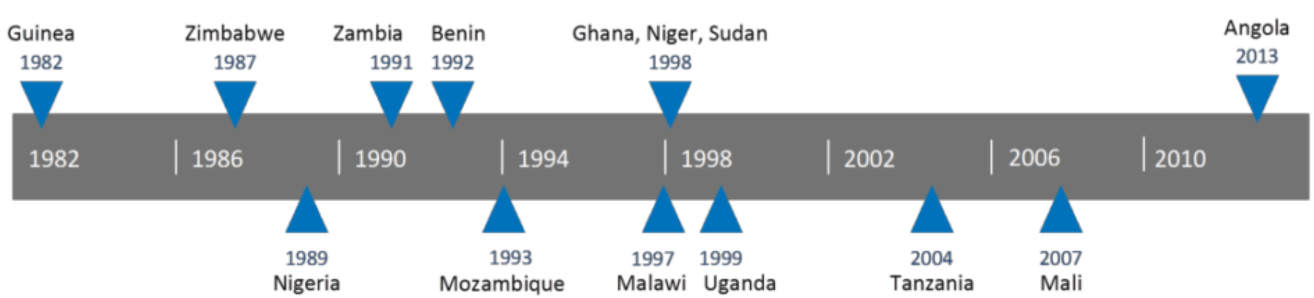
- Extensive resource - geological, chemical, electrochemical, and biological factors associated with corrosion
- Natural iron concentrations very rarely > 1 mg/L
- Less handpump usage = more serious high-iron problems
- Stainless steel pump rods had corrosion rates 10x less than GI



Were the lessons learned?



- Handpump standardization
- Institutional Memory
- Examples that the problem continued and persists today[3,8,9]



Source: MacAurthor, Jess (2015) *Handpump Standardisation in Sub-Saharan Africa: Seeking a champion.* RWSN Publication 2015-1. St. Gallen, Switzerland. www.rural-water-supply.net/en/resources/details/652

Perspectives on iron/corrosion

"The water is very red and not good when I come to pick water early in the morning. Many jerrycans must be filled before the water becomes clear"

- **Young girl using a handpump**

"The people here have stopped using the borehole because of the red water. They have gone back to open well" (referring to a traditional unprotected spring)

-**Village Leader**

"This borehole is too expensive – we must replace leaking pipes very often"

- **Water User Committee Chairperson**

"The people complain of high iron, but what can we do?"

- **Local Government Worker**

"We should educate these people so they know that iron is not a health problem"

- **Expatriate Water Quality Specialist**

"Iron is common in groundwater… we should find a way to treat the water for iron"

- **National Government Engineer**

RWSN: What is needed now?

(From Furey (2014) *Handpumps: where now? - A synthesis of online discussions (2012-2014)*[3]

- Avoiding the problem: mechanisms to ensure that galvanised iron (GI) pump components are not installed in aggressive groundwater (pH);

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- Avoiding the problem: mechanisms to ensure that galvanised iron (GI) pump components are not installed in aggressive groundwater (pH);
- Identifying the problem: a clearer understanding of whether high iron levels are caused by natural conditions or by pump corrosion, and;
- Addressing the problem: replacing of GI pipes and pump rods in all existing pumps in aggressive groundwater.

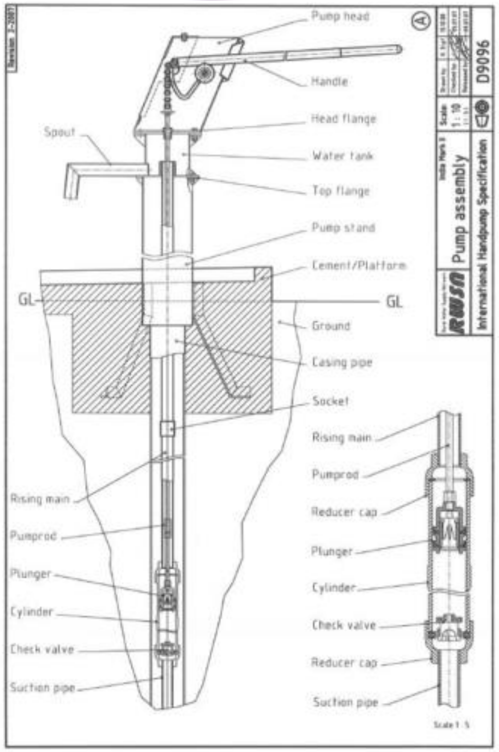
Uganda Context

Standardized handpumps

- <u>U2 (India Mark II) - Most Common Handpump</u>
  - 32mm rising mains
  - Standard with GI components
  - Can be fitted with Stainless Steel (SS) components
  - Special specifications for depths > 50m up to 90m

- <u>U3 (India Mark III)</u>
  - "Open-top" (OTC) handpump - 65mm rising mains
  - Typically with GI components
  - Can be fitted with Stainless Steel (SS) components
  - Limited to 50m

- <u>U3-Modified (U3M)</u>
  - "Open-top" (OTC) handpump - 65mm rising mains
  - Specified with PVC rising mains and SS pump rods
  - Limited to ~32m depths



Uganda Context

Existing pH data?

Chain-of-custody… storage / delays

"No water, no pay"

WaterAid Testing in Uganda

Partners

- Amuria and Katakiwi District Governments
- Church of Uganda-Teso Diocese Planning Development Office (CoU-TEDDO)
- Wera Development Agency (WEDA)

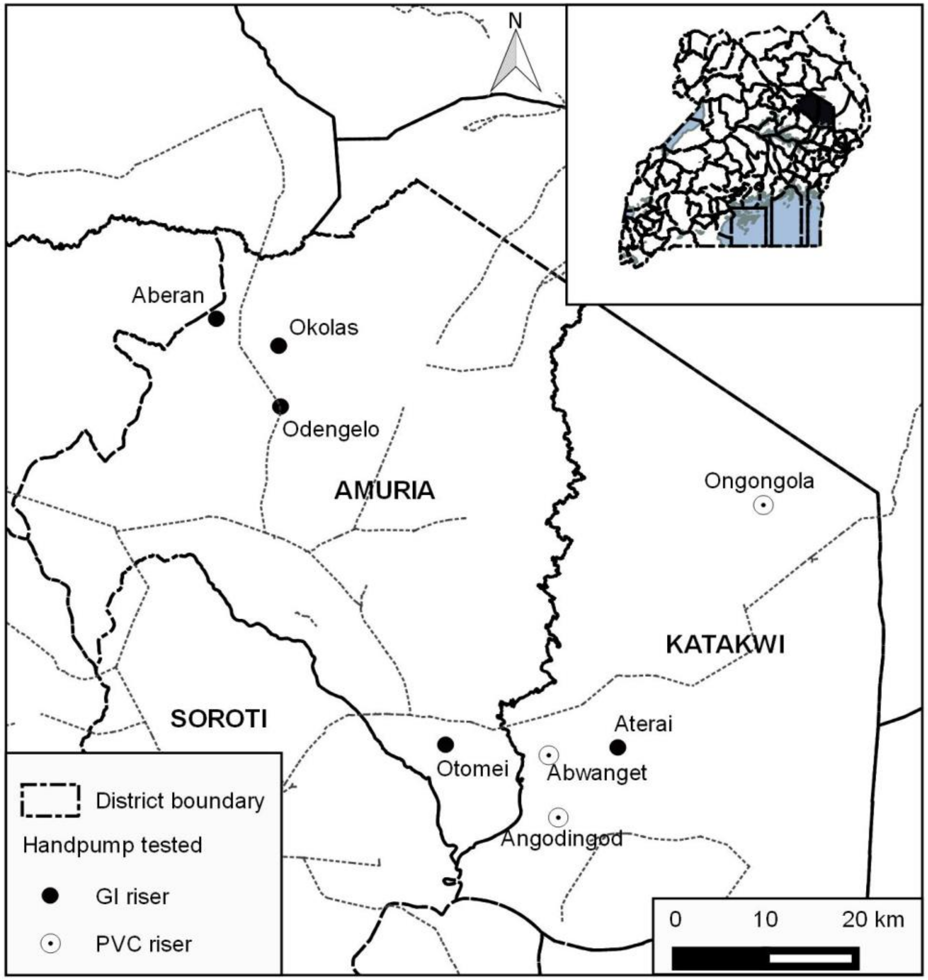
Steps taken

<u>pH testing</u>

- 34 boreholes in Amuria and Katakwi
- 91% < 6.5 and 38% < 6.0

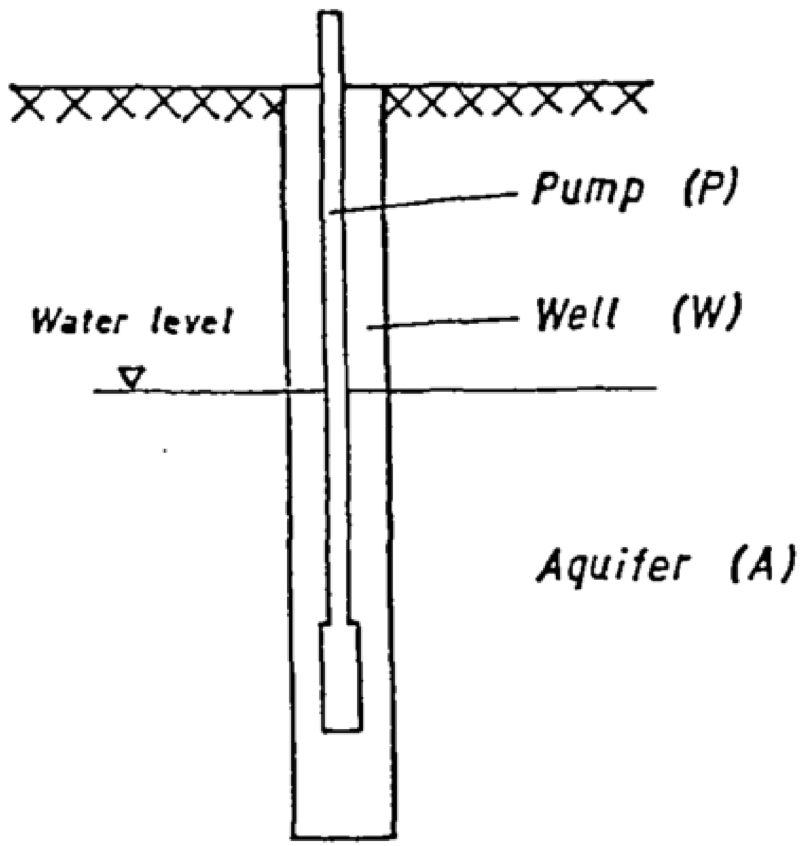
<u>Langenegger pumping tests</u>

- 8 boreholes in Amuria and Katakwi
- 5 with GI components
- 3 with PVC components



Pumping Test (Langenegger, 1989)

Groundwater Quality - An Important Factor for Selecting Handpumps (1989)[6]



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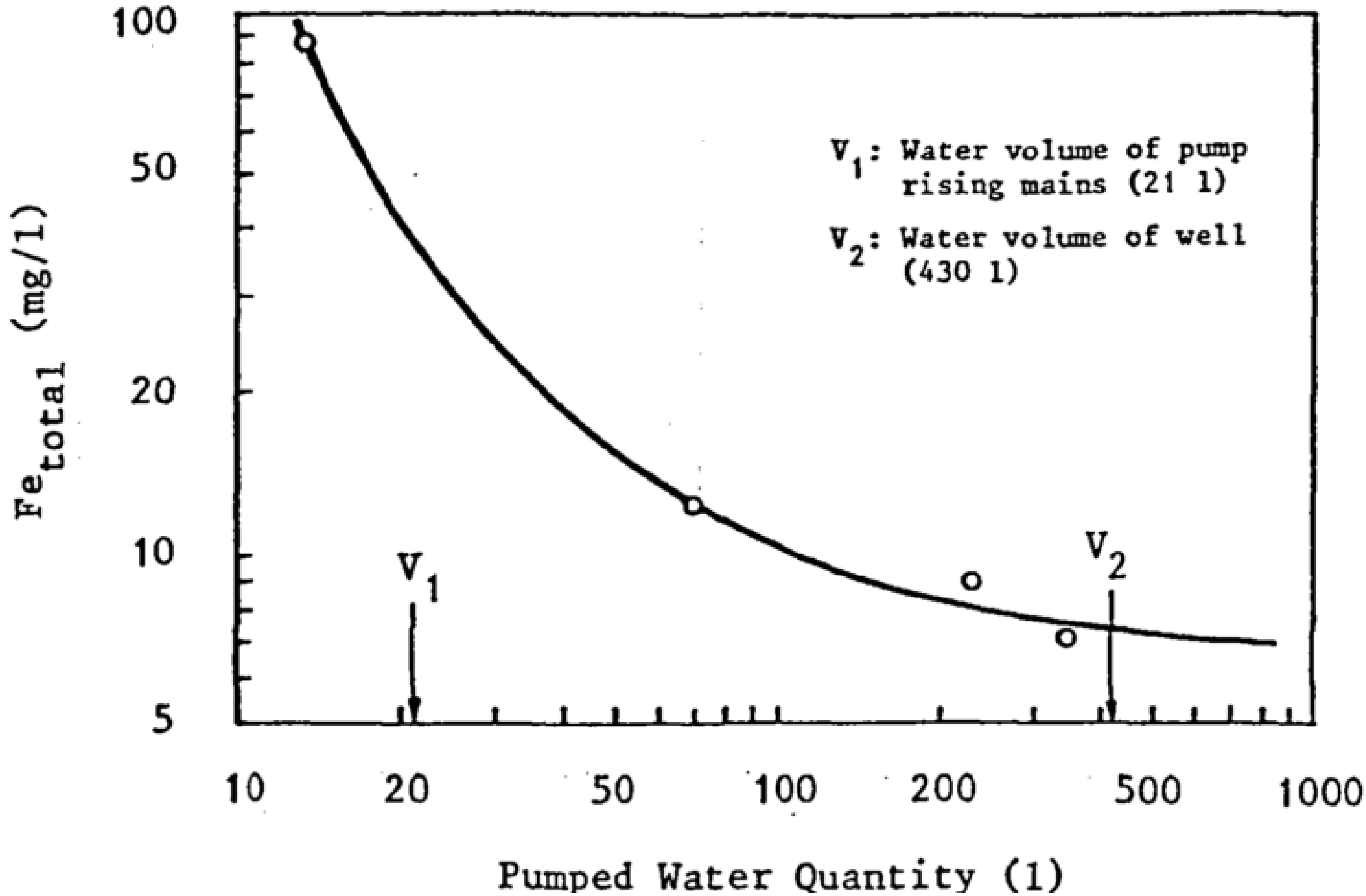
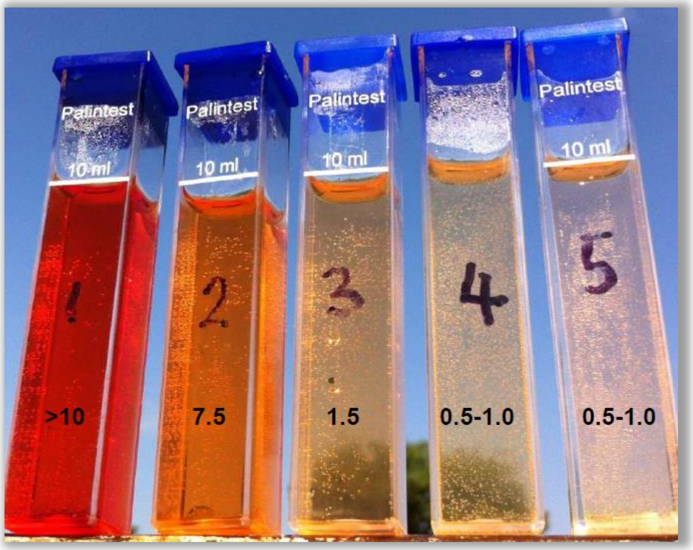


WaterAid Testing in Uganda

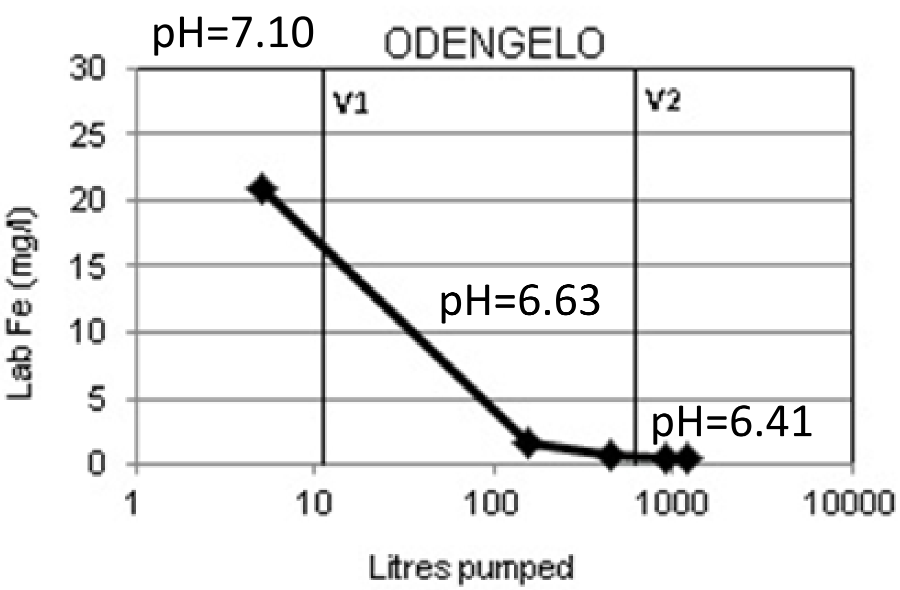
Pumping Tests

- Pumps locked overnight to ensure no use
- Iron assessed with Palintest comparator test
- Filtered samples to preclude solid corrosion (rust) particles from introducing error to iron tests
- Duplicate unfiltered samples and duplicate samples for analysis at MWE Lab for quality control

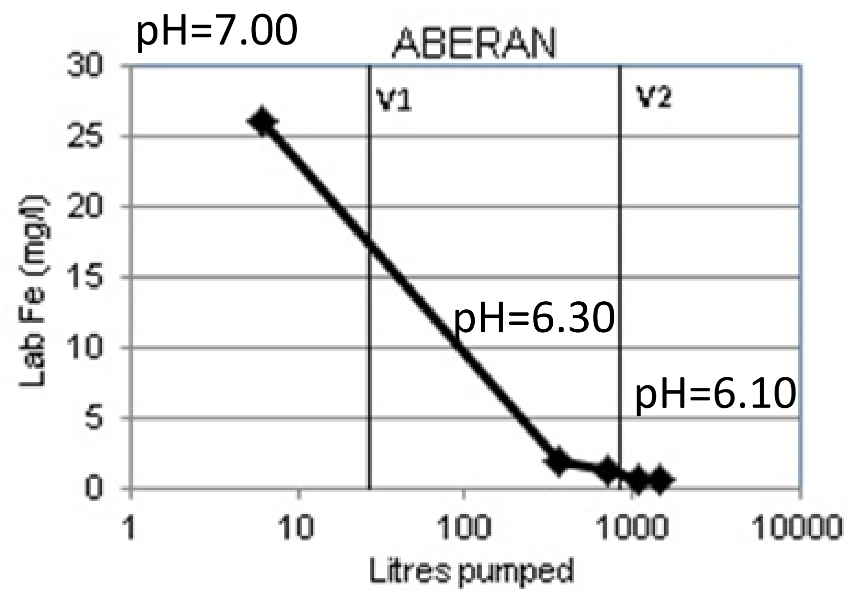
Testing in Uganda



Testing Results



litres	5	153	459	918	1,224
Palintest	>10	2.0 - 3.0	1.5	0.5-1.0	0.5
Lab (F)	21	1.6	0.77	0.45	0.5
Lab (T)	nt	nt	nt	nt	nt



6	360	720	1080	1440
>10	7.5	1.5	0.5-1.0	0.5-1.0
26	1.91	1.23	0.74	0.69
38	nt	nt	nt	nt

Observations

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Observations

Observations

<u>Abwanget – U3M Pump</u>

pH= 5.96 – 6.00 Aggressive!!

No change in iron concentration during pumping test – likely natural level at 0.5 mg/L

Conclusions

- Palintest Iron kit
- Filtration of samples
- GI components
- U3M
- U2 with PVC
- More research

Recommendations

- Policies / Planning
- Coordination / Communication
- Existing handpumps with high iron

- Implementation
  - Contracts – handpump selection
  - **On-site testing / Supervision**
  - Pumps in Uganda: U3M, U2 w/ SS, U2 w/ PVC

- Challenges
  - Awareness, training, supply chains, pump limitations,

Forthcoming Publications

RWSN

References

1. MacAurthor, Jess (2015) *Handpump Standardisation in Sub-Saharan Africa: Seeking a champion.* RWSN Publication 2015-1. St. Gallen, Switzerland. www.rural-water-supply.net/en/resources/details/652
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3. Furey, Sean (2014) *Handpumps: where now? - A synthesis of online discussions (2012-2014)*. RWSN / SKAT Foundation. St. Gallen, Switzerland. www.rural-water-supply.net/en/resources/details/614
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www.wateraid.org

Literature on handpump corrosion

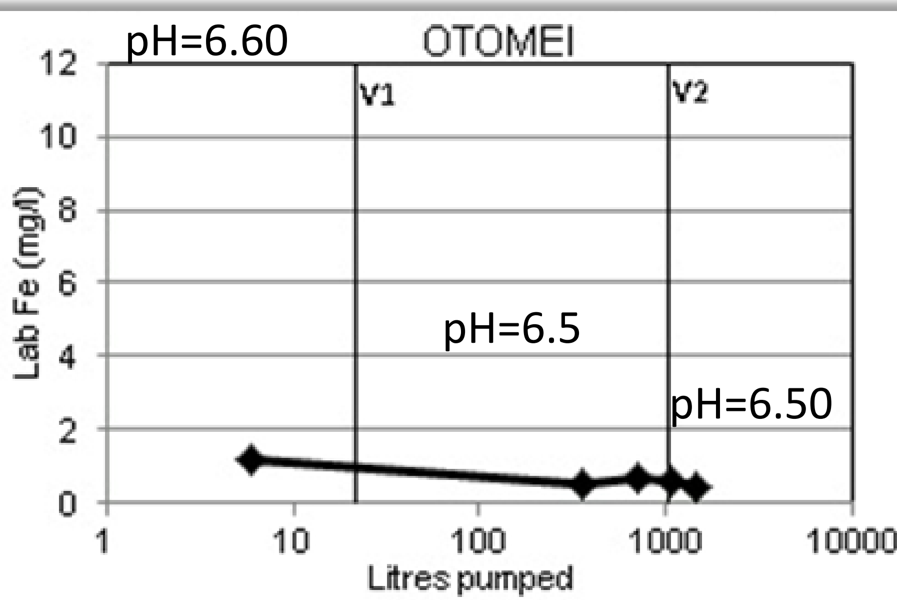
Groundwater Quality - An Important Factor for Selecting Handpumps (1989)[6]

Aggressivity has many factors, but pH is an indicative and simple measure

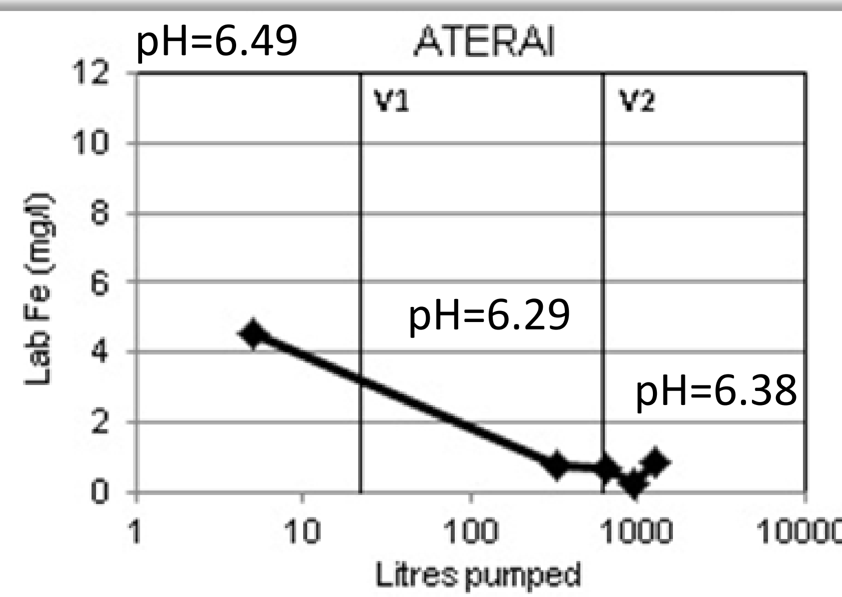
pH	Aggressivity of water	Application of galvanized material
pH > 7	Negligible	Suitable
6.5 < pH ≤ 7	Little to medium	Limited
6 < pH ≤ 6.5	Medium to heavy	Not recommended
pH ≤ 6	Heavy	Not recommended

EC also a useful indicator for galvanic (bimetal) corrosion, but related more to pump failures than to heavy iron-inducing corrosion

Testing Results



litres	6	360	720	1080	1440
Palintest	5	1.5	1.0-1.5	1.0-1.5	0.5-1.0
Lab (F)	1.17	0.49	0.67	0.63	0.48
Lab (T)	2.98	72	0.4	nt	nt



5	324	648	929	1296
>10	1.0-1.5	0.5-1.0	0.5-1.0	1
4.5	0.73	0.71	0.28	0.86
nt	0.67	nt	nt	0.75