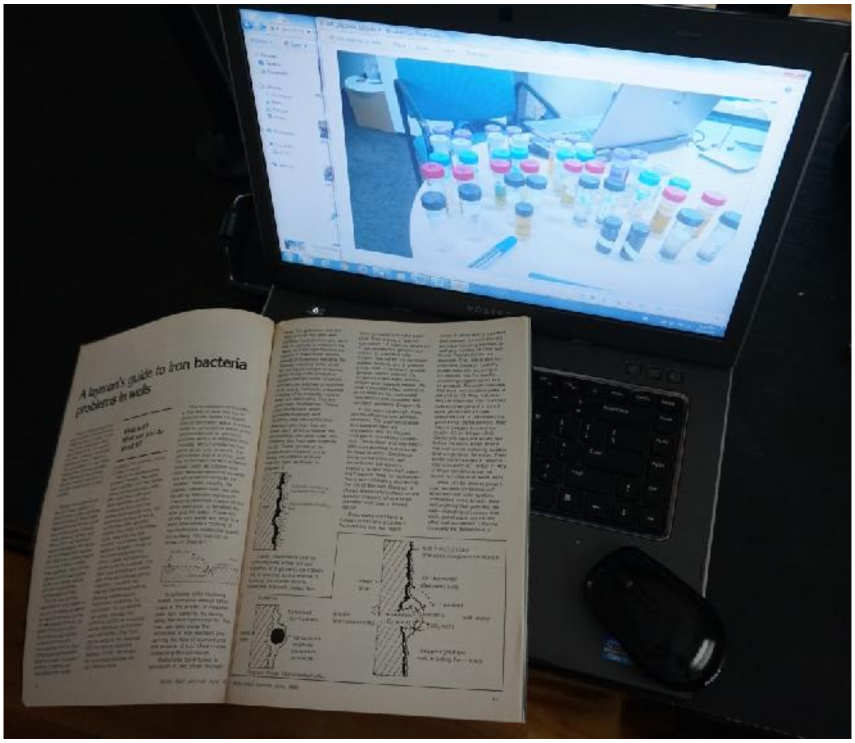

Reflecting on a 35-year "Life of Slime" or have we made any real progress in biofouling control in wells?

Stuart Smith

Time flies. Starting with the February 1980 issue of *Water Well Journal,* the technical magazine of the National Ground Water Association, I began a series on bacteria and their effects in wells in 1980 and 1981. At the time, I was a 25-year old staffer at the National Water Well Association with a still-shiny biology degree (the only one on staff, so I was the bacteria expert). This was before the refining discipline of masters' degree work at Ohio State under one of the original geomicrobiologists, Dr. Olli H. Tuovinen, and years of research, consultation, and collaboration since, almost all of it highly applied to practical situations.

This experience may seem familiar, along the lines of "where are the flying cars? Where are the hoverboards?" And biological problems of wells and water treatment systems are a pesky worldwide problem that I happen to work on.

In my opinion, the best of that first batch was June 1980's "A Layman's Guide to Iron Bacteria," in which I summarized briefly what we knew and experienced at that point, which was before the most recent revolutions in *almost everything* related to geomicrobiology and microbial ecology, analytical techniques for biofouling assessment, well rehabilitation methods, and the practice of asset management for wells (as opposed to "let it fail and drill another one").

Since then, during my "life of slime," I have written and taught extensively on the effects of iron and other biofouling (and its detection and control). These efforts have been heavily informed by our own hands-on consulting project work. The most recent major work was *Sustainable Wells* (2009, written with Allen Comeskey, CRC Press), and my work shepherding the latest edition of Section 9240, Iron and Sulfur Bacteria, in *Standard Methods for the Examination of Water and Wastewater*. Lately, I have been delving into the literature again for some presentations and projects, and of course, putting modern techniques and knowledge to work.

However, in looking at other articles, conference abstracts, specifications, and other evidence of the state-of-the-art in the ground-water industry serving water supply, I've had reason to wonder:

(1) Why there seems to be so little change in application (including lack of early intervention) despite exponential increases in microbiological knowledge and methods since 1980? This is while we know that there are severe limitations to technical methods, especially well cleaning.
(2) Why don't people who are in responsible charge of large-scale water wellfield assets and associated and expensive well regeneration and maintenance efforts apply known method improvements, even when they are practical and accessible?
(3) Why do well system designers make the same old mistakes? Good practice in well design was largely settled before I was out of college… in the era of punch cards and tape storage …
(4) Why do the ground water industry and the water sector using its services continue to look for a universal well-cleaning "silver bullet" and believe claims along those lines even when there is little objective evidence of effectiveness – beyond the short term especially?

Scientific diagnostic analysis is utterly practical and cost-effective: To get to a remedial solution that isn't one of a series of "try what the next vendor is selling," it is necessary to analyze the nature of the clog. Analysis is often avoided as it is viewed as costing something and "theoretical." Or (in the spirit of the age), "I don't need no science – I can hit it with a hammer and know what it is!" Inadequate analysis results mean missing out on components of the processes that drive clogging and corrosion in wells. For example, a well can be clogged by biological activity and mineral solids other than what seems obvious and the optimal treatment may be different than a snap judgment may indicate. Most clog mineral assemblages are mixtures, not just one thing such as manganese oxides. We have the ready tools to understand what's going on – and have had them for years:

- We have effective geochemistry technique. We have field instruments that allow testing of the process in real time.
- We have field-useful ("bush friendly") biological testing methods to evaluate reduction in bio-loading.
- We have biochemical microbiology methods that can be used to evaluate the origins of microbial communities and what they are doing, and how that changes due to operations and treatment. This is a frontier in applied science, but the practical cost-effectiveness possibilities are immense.

We do have the methods to objectively evaluate well rehabilitation events: Beyond the borehole video – No diagnostic analysis of wells is complete without effective hydraulic analysis. The step-drawdown pumping test and its analysis have been around for over 70 years – the method just needs to be applied professionally.

- There is a certain way to perform a step test
- The results must be analyzed – the client product is not just a chart of final specific capacities at the end of each, hurried step.
- We have spinner logs that can test the well intake profile to show where cleaning has been effective.

With these analyses, we can evaluate depth of penetration and changes in well loss that tell us how the cleaning event went. Video is helpful, but only shows the surface effects.

And what about the well rehabilitation (regeneration, cleaning) process itself?

Well cleaning specifications and execution: My 1980-era model of well rehabilitation was quite primitive, based around the then-common hydrochloric acid and chlorine procedure. Unfortunately, this is still the chemistry used by many. Is acid or chlorine ineffective? Use more.

We now have methods that permit effective application of development force over time at depth and under deep submergence. These range from long-used cable tool surging methods (available in 1980 – maybe even more widely than now) to very high-pressure jetting. These are often used in combination.

Claims: In paging through industry magazines, I see ads claiming to "eliminate iron bacteria" and the opportunities to profit by performing this marvel preached with revival meeting fervor.

Objective comparisons: We still lack any useful research comparing well cleaning or rehabilitation methods conducted so as to allow direct comparisons, such as in similar wells and conditions. This is certainly a difficult task as wells tend to be individual, even within a common wellfield. One such project was commissioned by the Water Research Foundation (formerly AWWA Research Foundation) but the results were not especially useful.

It would be possible to compare results in wells with common characteristics (similar enough construction, hydrogeology and water quality conditions) if useful pumping tests (usually a properly conducted step-drawdown test, that is, per Krusemann and de Ridder, 1994 or equivalent) were conducted before and after well rehabilitation. This remains an elusive goal, even for highly valuable wells. Consequently, evaluations tend to be subjective and difficult to compare.

So we all draw our own conclusions based on case histories. Selection of methods by end users is influenced disproportionately by sales technique.

Wells remain the orphan stepchild of utility asset management: AM is chic now in infrastructure management, but beyond including the pump and water level data in the data collection and service-interval system, tracking well deterioration is often overlooked. Well specific capacity can be readily calculated from total drawdown (if this is tracked) and pumping rate (if there is a meter), and this is a valuable calculation. However, it can be rather insensitive – much aquifer clogging can occur before there is a drop in specific capacity. Performance loss in wells has multiple components, which require analysis of step-drawdown testing to discern. Tracking changes in clogging causes and doing actual step-drawdown pumping test analysis results in more timely maintenance and planning better well rehabilitation.

Asset management? We just have a house well! You maintain your vehicles, don't you? You wash them, apply coatings, change oil, perform regular checkups… Your vehicles cost a fraction of your house (most of the time). Your well (along with a waste removal system) makes the house habitable if you are not on public utilities. You and your family and visitors drink the water. Wells are like vehicles in that 1) they are mechanical systems expected to perform with little drama, 2) they are constantly exposed to an environment determined to change them back to natural materials, yet 3) they are expected to provide a quality experience and protect your safety.

It is gratifying to see that our efforts starting over 30 years ago have been part of a revolution in well asset management and rehabilitation. We see concepts we helped develop or popularize more than 20 years ago being part of the common vocabulary of water supply. However, the same vocabulary can be useful in selling "sizzle and sauce."

There have been true improvements in all aspects of detecting, rehabilitating and maintaining wellfield assets. Unfortunately, all are still poorly adopted by water systems management, even in the face of the many advantages.

That's what is really disappointing – poor adoption of better ways even after decades of publications and presentations: people in responsible positions not paying attention.

Perhaps that can change in the years ahead.