BLOCKCHAIN BIOSOLIDS: How Digital Technology Can Revolutionize Biosolids Management

“Trust and Transparency,” that is the promise. I was snagged by the Facebook Ad offer for a lecture by George Gilder on how the coming revolution in digital technology would protect privacy, honor creativity, and guarantee security, hence accomplishing “trust and transparency.” If I had two words to describe what biosolids managers are missing most in their work with customers, community, and regulators it is those very things - trust and transparency.

I ordered for $13 Gilder’s book, Life After Google. This was not much of a risk in my mind. After all, I had intended to learn more about 5G, bitcoin, blockchain, and other terms that have been entering the lexicon of savvy professionals. And if I could learn how to achieve “trust and transparency,” $13 was worth the risk.

Wastewater professionals see themselves as the “hidden infrastructure.” Compared to roads and bridges, that is true, but compared to the digital infrastructure, we do not compare. Even the very digitally “woke” among us are likely to see the digital infrastructure as opaque. Yet the scale is beyond most imaginings, with a typically large data center a million square feet, costing a billion dollars to build and requiring 100 MW of power. These comprise not a culmination of technology investment, but a way station on a moving sidewalk that has not slowed over the decades. That the “cloud” now shapes much of the way even wastewater managers upload and download facility data, against a recordkeeping approach that is keyboard-typed spreadsheets on desktops, the next step may involve “sky” technology and a system of data reading that bypasses human eyes, comprising “life after Google.” George Gilder’s book is an introduction into the post data-center world, that of networked supercomputers, laptops, and cellphones in vast, distributed relationships. Pulling these together is "Distributed Ledger Technology (DLT)," also known as Blockchain Technology. The “block” in blockchain are "transaction blocks," information units that are assigned a "cryptographic code" to which participants in the transaction have secure access.

The global digital revolution has not greatly transformed municipal wastewater treatment. But what might biosolids management look like if a “Life after Google” type transformation took hold? Bitcoin is the most familiar transaction block that is tracked by DLT, but what if a load of biosolids was just such a block?

Digital records of today’s biosolids processing and use are not deliberately “chained” together. But what if we changed that? What if, with DLT, or Blockchain Technology, the data we could collect at every step of the biosolids value-chain, from influent, through the WRRF, out to the user and into the soil or energy facility, were the input to Blockchain Biosolids records? A large, and increasing, number of monitoring, reporting and verification data (MRV) could be collected and “chained:” sensing influent quality, measuring nutrient and pollutant concentrations, reporting processing statistics, tracking transportation movements, documenting land applications, connecting to crop yields and soil test results, matching to unmanned drone photos, estimating carbon sequestration, nitrogen and phosphorus loadings to farm soils, and connecting to odor complaints. These data could be used for complying with regulations, monetizing nutrient trading, and meeting agronomic targets. Farther in the future, as wastewater systems work to improve effluent quality, blockchain networks can be used to track, for instance, the surveillance of pollutants in consumer products and pathogen releases to sewage. The digital revolution and data management through blockchain could empower treatment plant owners to accomplish improved biosolids quality.

The first step on the Biosolids Blockchain is wastewater quality. Wastewater surveillance is an upcoming digital technology that ought to benefit the quality of biosolids. The 2019 WEFTEC paper "Effective Utility Management in a Digital World" speaks to a Memphis project with "the opportunity to intervene on pollutants and to maximize the destruction of pollutants and biological constituents." The novel coronavirus has ensured a place in popular culture for a growing interest in sensing influent pathogens (Computational analysis of SARS-CoV-2/COVID-19 surveillance by wastewater-based epidemiology locally and globally: Feasibility, economy, opportunities and challenges). But researchers have targeted poliovirus (Evaluation of Secondary Concentration Methods for Poliovirus Detection in Wastewater) and other compounds public health interest (24-hour multi-omics analysis of residential sewage reflects human activity and informs public health), such as illicit drugs, smoking prevalence and dietary habits (e.g., Alcohol and nicotine consumption trends in three U.S. communities determined by wastewater-based epidemiology and in the Assessing the Potential To Monitor Plant-Based Diet Trends in Communities Using a Wastewater-Based Epidemiology (WBE) Approach).

The second step of Biosolids Blockchain is treatment plant performance. Digital technology promises a future of optimized effluent treatment. It could be something apparently easy, such as Evaluating the performance of a simple phenomenological model for online forecasting of ammonium concentrations at WWTP inlets; this is a report of an effort to optimize energy and chemical inputs for aeration and nitrogen removal. WRRFs of the future could be highly automated, monitored in real time and controlled remotely, as offered in this article Augmented reality, an ally in water treatment processes. The "holy grail" is a fully integrated system for an entire plant, as envisioned in Artificial Intelligence in Wastewater Treatment Facilities: Implementing Practical New Technologies for the End User. Accenture Water Analytics, IBM Intelligent Water Platform and Veolia Water Technologies Aquavista are three initiatives in the smart wastewater space.

Two stops in the treatment plant seem to cry out for digital enhancement of the biosolids "value chain." The first is automated control of stabilization, e.g., anaerobic digestion. Automatic process control in anaerobic digestion technology: A critical review evaluated available automatic control technologies that can be implemented in AD processes at different scales, and other papers (Lessons learnt from 15 years of ICA [instrumentation, control and automation] in anaerobic digesters and Nonlinear process control of anaerobic sludge digester) offered cautious notes about the practicability of digitally-guided operations, even as such tools as "proportional-integral-derivative (PID) controls," "fuzzy logic controls (FLC)," neural networks, and artificial intelligence are applied. The second stop for digitally enhanced biosolids "value chain" is dewatering. Optimal solids content in biosolids is an interplay of feed quality, chemical inputs, and equipment settings to which sensors and feedforward and feedback control logic can be applied. Three leading offerings in this area are Valmet, with its dry solids measurement equipment, Hach with its RTC-SD (Real Time Controls for Sludge Dewatering), and RealTech on sensors of excess polymer dosing. Each point of data collection is a "block" in the chain of information on biosolids quality.

After a Biosolids Blockchain record has taken in data on influent quality, stabilization performance and dewatering, the next stop on the value chain for data collection is transportation of biosolids loads to the user or customer. Over the past decade, the vehicle tracking system is nearly universally adopted, providing origin and destination data of biosolids haulage, matching weigh tickets issues at the production plant with records at the field.

Precision agriculture sets a high bar for digitalization of farming operations. Documentation of field application of biosolids is the next step in blockchain. John Deere introduced two decades ago its GPS guidance systems to record farm tractor operations, and the firm even has the HarvestLab 3000 "manure constituents sensing laboratories" outfitted on manure application equipment to calculate in real time nutrient applications. An up-and-coming technology is UAVs, or "unmanned aerial vehicles" that can check on nutrient needs, soil conditions and equipment operations (see, for instance, The Role of Drone Technology in Sustainable Agriculture.) At harvest time, digital equipment can estimate crop yield, as with the John Deere ActiveYield. Were digital information collected at the farm site of biosolids spreading and crop performance, this would be another block added to the chain, with the connection between biosolids and crop growth objectively documented.

Biosolids recycling benefits soil, and blockchain can provide the records demonstrating this benefit. The United States is an international leader in creating digital agricultural laboratories. Major issues in agricultural use of biosolids, such as soil phosphorus accumulation, pollutant concentrations and soil organic matter, are all subject to analytical documentation through soil tests. Analytical reports of soil samples linked to biosolids applications in time and location can be exported automatically from the laboratory to the biosolids blockchain records. With this data record, the blockchain is complete, from influent through to soil.

Global climate change is an urgent issue about which biosolids managers can play a role, particularly if blockchain is part of rigorous recordkeeping system from which biosolids managers work. This opportunity is offered, for example, by green technology investment advisors in The Time is Now: The Blockchain Platform for Carbon Offsetting, Green Financing and Sustainable Investments. Privately funded ventures propose deploying "value-chain incentives" for carbon sequestration, as with the "deep demonstrations of turning landscapes from carbon sources to sinks" described in About Landscapes as Carbon Sinks. The rigor of the blockchain data system can make this possible for the wastewater profession, as it facilitates conformance by our industry to rigorous procedures for carbon accounting. For instance, the Soil Enrichment Protocol: Reducing emissions and enhancing soil carbon sequestration on agricultural lands is nearing adoption by the Climate Action Reserve.

The wastewater profession's capacity to collect data on processes and practices has typically outstripped its capacity to draw out knowledge and meaning from that data. The kind of digital revolution and "internet of things" that has propelled Google and others to the world's center stage has widened the gap between our customary practices and the reasonable expectations of our customers for how environmental technologies ought to work in a digital world. The "trust and transparency" that seems to be missing in our relationship with customers and neighbors is not an intentional strategy but rather a failure to invest talent and resources in bringing digital technology solutions to biosolids management. We need a digital revolution, and that revolution can begin by **Embracing Blockchain Biosolids.**