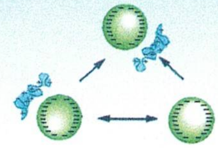
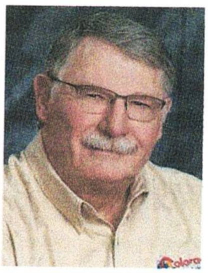
Electrocoagulation Applications for Wastewater





BY Dave Diss
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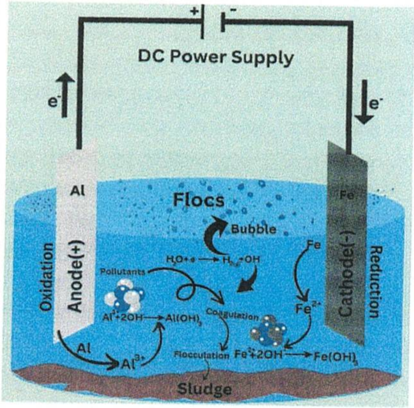
While working in Western Colorado back in the 1980s as an environmental specialist for a major energy company, I was introduced to the process of electrocoagulation for the treatment of hydrocarbons in industrial wastewater. Physics and chemistry being right in my wheelhouse, the technology fascinated me. The process of applying a small electrical current to metal plates submerged in the produced water for the separation of the particulates just seemed like it should work! We were always looking for solutions to remove contaminants from wastewater associated with hydrocarbon extraction. Though the process of electrocoagulation for wastewater had been around since 1906, it was still an imperfect science.

The conventional wastewater treatment processes use filtration and ultrafiltration, ion exchange, chemical applications, reverse osmosis, or biological methods to remove contaminants. However, the *new and improved* technology of treating wastewater via electrocoagulation has gained attention once again due to its smaller footprint, efficiency, eco-friendly, and cost-effective methods, while producing the least amount of sludge without chemical additives. As a result, **Electrocoagulation** now presents itself as a viable treatment technology.

Simply put, electrocoagulation means solidifying, or semi-solidifying, a solution of liquid and suspended solids by passing an electrical current through it. Clean electricity properly applied will cause a multitude of water contaminants to become separable from water. This procedure separates flocculated particulates from the water, enabling them to be removed, leaving behind only the clean, purified water.



Electrocoagulation is a treatment process that combines the advantages of *coagulation, flotation, and electrochemistry.* This technology can produce a high-quality effluent, with the removal of 90-98% of heavy metals such as lead and copper, along with both organic and inorganic pollutants. The EC process also removes emerging contaminants like radionuclides and forever contaminants like PFOS, and PFAS.

The Process

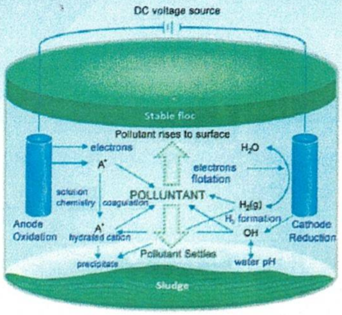
The method uses an electrolytic cell with an anode and a cathode to destabilize the charges, both of which are stimulated by a DC power source while using pairs of parallel conductive metal plates. During this process, the positive side undergoes anodic reactions, while the negative side goes through cathodic reactions.

Consumable metal plates, such as iron or aluminum, are usually used as sacrificial electrodes to continuously produce ions in the water and must be replaced periodically. The released ions neutralize the charges of the particles and begin coagulation. These ions remove undesirable contaminants either by chemical reaction and precipitation or by causing the colloidal materials to come together. Afterward, the flocculated particles can then be removed by flotation, or by any other secondary separation method.

Additionally, as water containing colloidal particulates, oils, or other contaminants move through the applied electric field, the physical and chemical properties of water and contaminants will alter. As a result, the electrons or reactive state destabilize the material in the water creating oxide sludge that can be separated making the treated water clean for discharge or for water reuse.

The electrocoagulation process also has the ability to remove 95-99% TSS, reduce BOD by 50-98%, and bacteria by 95-99%.

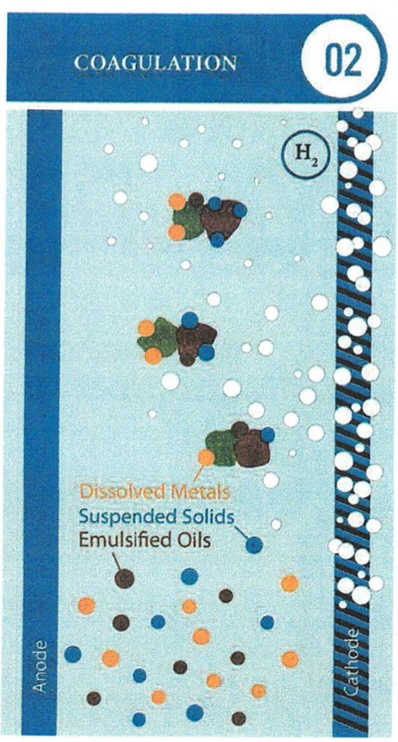
During electrocoagulation, metal ions are generated at the anode while hydrogen bubbles are released at the cathode. These hydrogen bubbles are responsible for the flotation of formed flocs to rise to the surface of the reactor where they coagulate and are removed.



"Electrocoagulation may soon move from the optional treatment method to the essential treatment method as the US EPA begins to enforce the laws protecting the environment from toxic wastes, including heavy metals."
—Powell Water Systems, Inc.

The efficiency of EC depends on the best combination of several processes.

- **Precipitation** is one key mechanism of the EC process. The metal hydroxides created from metal ions in the water settle to the bottom of the reactor, can then be extracted, and collected in a much purer form.
- **Adsorption** is another key mechanism in electrocoagulation. This process involves the removal of the impurities when they become adsorbed onto the surface of the plates. This process is especially effective for the removal of organic pollutants from the water, such as oils and grease.
- **Coagulation** is the last step of the EC process. Once the impurities are flocculated, they can be removed from the water through either sedimentation or filtration. This part of the process is particularly effective for removing bacteria and microorganisms from the water.



The Case for Metals

While the ion exchange process has been used to remove heavy metals in wastewater, it can only remove *low concentrations of contaminants* before the resin becomes oversaturated and requires regeneration. Electrocoagulation, however, is capable of processing wastewater with *higher concentrations* of these metals quickly and efficiently. In fact, one of the primary applications of the EC process in wastewater treatment is the ability to remove heavy metals from water. Using the precipitation mechanism, the metal hydroxides that have been created from metal ions in the water settle to the bottom of the reactor where they can be removed.

What about PFAS?

The chemical properties that make PFAS useful as stain repellents in carpet and clothing, as well as in firefighting foams and other industrial processes also make them resistant to treatment in wastewater processes, and they often end up in biosolids and landfills. These are the dreaded "forever chemicals", or "chemical rebar" as they are known since they never break down.

However, new electrocoagulation treatment technologies have been developed by a local Colorado company that not only separates the PFAS from water but also breaks the carbon-fluorine bond of these long-chain carbons, removing them in less than three minutes and converting them into inert safe environmentally friendly solids. What remains is purified water for reuse or discharge. This electrocoagulation process has been shown to reduce PFOA and PFOS below-proposed discharge limits for leachate water and coagulated solids under three conditions with the new ***Powell Water*** EC process, using the aluminum blades, aluminum & iron blades, or iron blades with hydrogen peroxide. By destroying the fluoride carbon bond, the environment is safe from PFOA and PFOS contamination. The new simple and cost-effective process is "the best way to eliminate PFAS, PFOA, and PFOS."

The Advantage

The EC process is an environmentally friendly method that requires minimal personnel training, no chemical additives, or expensive equipment. Without the need for chemicals, there is no danger of residual chemicals being released into the effluent, the cost of the chemical coagulation process is eliminated, and there is no need for chlorination for the reduction of odors and toxins. Additionally, there is only a low level of current consumed in most cases, making it easy to produce using green energy.

Wrapping it up

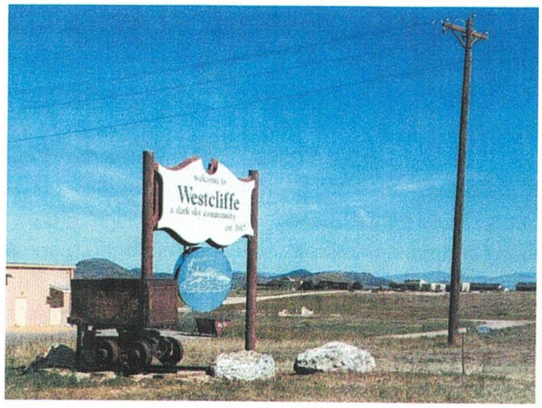
As the years have passed since my days as an environmental specialist in the energy field, I've thought many times about why electrocoagulation just wasn't viable for removing these nuisance contaminants from wastewater. It just didn't make sense that it wouldn't work. Recently though, I've had the opportunity to learn that it **IS** indeed viable. Not only that but it's become one of the very few processes that break down and neutralize contaminants and leave very little waste. I learned that it's the thickness and spacing of the plates and the proper DC current that make this excellent process function. It's very interesting to see the advancements in this technology through the application of physics and chemistry that make this treatment process such a great option for the removal of all types of contaminants.

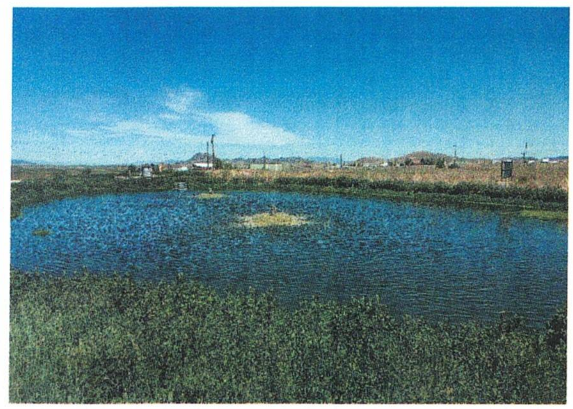
A wide variety of wastewaters can benefit from an electrocoagulation treatment process. Replacing traditional chemical and filtration treatment processes, EC has been proven to reduce operational costs with significant benefits, utilizing its ability to remove a wide range of impurities and produce high-quality effluent. **C** feature

EWQMS/Round Mountain W&SD Electrocoagulation Pilot Project

Proving an Alternative to 'Mechanical' and 'Evaporative Lagoons'

BY KELVIN (KELLY) STONE
Energy Efficiency Technician





PROBLEMS:

1. *Round Mountain Water and Sanitation District (W&SD) Wastewater Treatment Plant (WWTP) needs an upgrade to meet discharge permit requirements (to meet new 303D Stream Water Standards). Much lower nitrogen requirements cannot be met with the existing wastewater treatment process (aerated lagoon system).*
2. *Energy costs for RMW&SD are substantial due to lower efficiency motors utilized for aeration and transfer pumping.*

Energy and Water Quality Management System (EWQMS):

EWQMS is the optimization of energy management (electric load/usage based on 'time of use', and 'demand rates') with limiting consideration of water quality requirements.

Water (and wastewater) operations depend heavily on the use of electric equipment including aerators, HVAC, motors/pumps, and related control systems.

EWQMS:

The concept of an EWQMS is to optimize energy management to improve operational efficiency and lower cost while ensuring water quality requirements are met.

In practice, EWQMS attempts to 'optimize operations' through the use of software applications:

EWQMS:

- predicts daily water flows and energy consumption.
- determines unavailable electric equipment (that could impact operation performance)
- determines predicted hourly/daily energy costs (based on rates and 'time of use' – TOU)
- determines predicted water quality limitations (based on flow rates, volume, and equipment availability)

Examples of EWQMS-related operational optimization opportunities include:

- reduced aeration scheduling based on dissolved oxygen monitoring (utilizing SCADA, free oxygen from algae photosynthesis, improved diffused aeration efficiencies)
- monitoring of power consumption, optimum scheduling of energy-consuming equipment based on 'time of use, and avoidance of demand charges resulting in energy cost reduction
- monitoring of pH, alkalinity, and oxidation-reduction potential (ORP), water flows (utilizing SCADA), to optimize nitrification/denitrification (managing anoxic zone) to meet water quality requirements
- monitoring of VFD settings, amperage, flows, frequency/speed of motors/pumps (utilizing SCADA), to optimize motor operation/scheduling and reduce energy cost.

Existing Round Mountain W&SD WWTP Description:

The existing WWTP utilizes floating aerators to provide needed oxygen to lagoon cells (providing biological treatment of wastewater). Aeration results in oxygen supply (in addition to oxygen produced by algae based on photosynthesis on

SOURCE: RMWSD.COM

sunny days). However, floating aerators are not efficient at the transfer of atmospheric oxygen to lagoon bio-organisms. Additionally, floating aerators are energy inefficient in comparison to diffused air systems. The current treatment process is inadequate to remove nitrogen (also arsenic and phosphate) for discharge permit compliance.

The current RW&SD WWTP provides wastewater treatment with three lagoon cells (cell #1 – 2 aerators, cell #2 – 3 aerators, and cell #3-polishing cells with no aeration). Improved nitrogen removal is necessary to meet much lower discharge permit nitrogen requirements (also arsenic and phosphate levels).

Proposed Round Mountain W&SD WWTP Description:

Expansion of existing lagoon cells is necessary (with required lining to prevent leaching) to accommodate nitrification/de-nitrification for nitrogen removal.

The addition of electro-coagulation equipment is proposed for the removal of contaminants, (including potential algae discharge). The use of customized microbes (cultivated onsite) specific to removal requirements, is also proposed. to facilitate the removal of certain contaminants. Replacement of lower-efficiency floating aerators with micro-bubble air diffusion units are proposed to improve available oxygen for lagoon microbes, improve treatment, and lower energy costs.

Summary of Equipment, WWTP Modifications and Operational Changes for Project Implementation:

Equipment:

- Electro-Coagulation System (to provide advanced treatment necessary for a discharge permit compliance)
- Floating Micro-Bubble Air Diffuser System (to replace existing aerators and improve the efficiency of oxygen transfer and reduce energy cost)
- Premium High Efficiency (PHE) motors (to replace existing transfer motor/pump system)

WWTP System Modifications:

- Excavation of existing lagoon cells, with lagoon cell lining to prevent leaching of contaminants to groundwater
- Installation of micro-bubble diffused aeration equipment
- Installation of electro-coagulation (EC) equipment

Operational Changes to Achieve Goal of Permit Compliance:

- Grow customized microbes and inoculate modified lagoon cells to optimize biological removal/treatment of wastewater
- EWQMS related software and SCADA modifications, sensors and wiring to enable optimization of WWTP scheduling (aerators/pumping) and monitoring (power consumption, flows, water quality parameters/sensors)
- Operation of EC equipment to optimize contaminant removal

To learn more about EWQMS, and the Round Mountain W&SD Electrocoagulation Pilot Project, and the viability of 'Proving an Alternative to 'Mechanical' and 'Evaporative Lagoons', contact Kelvin (Kelly) Stone, kstone@crwa.net C