United State Department of Agriculture | Agricultural Research Service | National Program Staff | Beltsville, Maryland 20705

December 18, 1995

SUBJECT: Electrocoagulation

TO: Scott W. Powell
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FROM: W. Doral Kemper *Doral*
NPL, Soil Management

I had promised each of you a copy of what we sent to the Deputy Secretary. I received the final version today (see enclosed). The draft had a few more things in it which we decided the Under Secretary would not find time to read. Perhaps you will!

At any rate, I enjoyed learning a bit about "electrocoagulation".

In case the two of you have interest in contacting each other, your phone numbers are:

Powell 801-569-0465
Bouwer 602-379-4356

Enclosures

Return to W D Kemper

INFORMATIONAL MEMORANDUM FOR THE DEPUTY SECRETARY

THROUGH: Karl N. Stauber /s/ Karl N. Stauber 3 DEC 1995
Under Secretary
Research, Education, and Economics

FROM: Floyd P. Horn /s/ Floyd P. Horn DEC 13 1995
Administrator

SUBJECT: Electrocoagulation

ISSUE:

In response to your request on November 24 for comment on the process of electrocoagulation, as presented to you by E. C. Systems, Inc., we submit the following.

DISCUSSION:

The Basic Process Involved. In essence, the process consists of forcing the contaminated water to flow rapidly (4 meters/second) between closely spaced (3 mm apart) iron or aluminum electrodes, across which a slowly alternating (reversing about every 10 seconds) electrical potential (that can be adjusted between 2-100 volts) is applied. When the contaminants are heavy metals in cationic form, they generally precipitate as hydroxides or oxides since the electrode potentials are also sufficiently high to induce reduction and oxidation reactions. When the polarity reverses, there is a tendency for the metallic oxides, hydroxides, and some hydrogen gases to be swept from the electrodes by the rapidly flowing water into the clarifying chamber where the water moves slowly. The crystallization process appears to continue in the clarifying chamber as unreacted metallic ions and freed oxygen and hydroxyl ions are incorporated into the growing metallic oxides crystals.

Most of these crystals of the metallic oxides and other coagulates settle to the bottom of the clarifier becoming a sludge. A smaller portion of them are floated to the surface by small attached bubbles of the gases where they become observable as a foam. The contaminant sludge is pumped out of the base of the clarifier and the contaminant foam is vacuumed off the surface into their respective filter baskets, while the cleaned water discharges from a vent near the surface of the clarifier. In some cases the contents of these sludges are of sufficiently high value and volume to justify their processing into useable byproducts.

Colloid size contaminants dispersed in water generally bear net charges, which cause them to be attracted to one or the other of the electrodes, causing them to coagulate with other particles. Living organisms such as pathogens are essentially electrocuted by the electric current flowing between the electrodes.

The efficiencies with which various contaminants can be removed are determined by settings of the voltage across the electrodes, timing of reversals of polarity on the electrodes and related factors which E. C. Systems has optimized, based on their experience, to fit the needs of their customers and the specific components involved in the contamination.

Capacity of the Equipment and Costs of the Process. Units of their most common size of these electrocoagulation systems cost about $150,000 and process 25 gallons of water per minute (about 95 liters/minute). We estimate the total cost (operations, maintenance, and equipment) of electrocoagulation per thousand gallons of water for these units at from $2 to $8 depending on the type and amount of contaminant to be removed. They also have developed prototypes for household culinary and drinking water which will fit under kitchen counters, process about one quart of water per minute, and cost $200.

E. C. Systems' customers that we contacted support the claims to better than average cleaning of contaminated waters, with less sludge to be disposed and relatively low cost with electrocoagulation compared to chemical coagulation.

Potential Benefits for Agriculture and Rural Residents Using Electrocoagulation.

1. Cleansing water to be used for drinking and culinary purposes. In areas where ground water supplies are saline, otherwise contaminated with undesirable components, or are nonexistent and surface waters are being used for culinary supplies, electrocoagulation appears to be a good candidate for removing many contaminants from those surface waters. Its apparent ability to kill pathogens is particularly relevant in terms of recent concerns regarding cryptosporidium, which is resistant to chlorination. The National Sanitation Foundation has developed protocols for evaluating performance of systems designed to produce water for culinary use. In areas where cryptosporidium, other water born pathogens, or other contaminants are known to be problems, electrocoagulation might also be considered as a means of improving water to be used by livestock.

2. Renovating food processing waters. This could include killing of pathogens in waters from meat processing plants, removal of heavy metals, phosphorus or other chemical contaminants, and recovery and sterilization of fats, proteins, etc., from these waters, which might be used for animal feeding.

3. Renovation of waters used in textile and paper manufacture. This could include removal of dyes, inks, bonding agents, etc., from those waters.

4. Renovation of waters used in washing. This should include: water used in dip vats for disinfecting animals, water used to rinse sprayer equipment, water used to clean truck and tractor engines, wash down milking parlors, etc.

5. Cleansing septic tank waters. Such cleansing might be particularly beneficial in areas where septic system density is high, or in proximity to wells, or where soil conditions result in occasional macropore formation and escape of septic waters to ground or surface waters.

Past and Current ARS Research Related to Electrocoagulation. ARS studies conducted in the fifties and sixties on electroosmosis, electrophoresis, and polarographic analysis validated some of the basic principles involved in electrocoagulation. Currently, ARS has a project at Albany, California, where use of electrocoagulation as a means for renovating food processing water for reuse is being evaluated. This project involves about 20 percent of the research of one scientist.

SUMMARY:

The electrocoagulation process developed and marketed by E. C. Systems, Inc., is based on valid scientific principles involving responses of water contaminants to strong electric fields and electrically induced oxidation and reduction reactions. This process is able to take out over 99 percent of some heavy metal cations and also appears to be able to electrocute microorganisms in the water. It is also able to precipitate charged colloids and remove significant amounts of other ions, colloids, and emulsions at costs ranging from $2 to $8 per thousand gallons of water. When the system is in place, the operating costs including electric power, replacement of electrodes, pump maintenance, and labor can be less than $1 per thousand gallons for some applications.

Potential applications to agriculture and quality of rural life include removal of pathogens and heavy metals from drinking water and decontamination of food processing and wash waters.

ARS has conducted research on related processes in the past and has a small ongoing research project on use of elecrocoagulation to renovate food processing waters.

ARS:NPS:WDKemper:mkm:12-11-95