Contaminant Removal Mechanism in Wastewater Treatment
Concept, Application and Utilities

Shubha Sudheendra
FLAGSHIP EcoSystems Pte Ltd., 4 Shenton Way #06-01 SGX Centre 2 Singapore – 068807,
Telephone: (65) 6536 1110 E-Mail: shubha@ecoflag.com.sg

Abstract
Contaminant removal technologies figure a robust base for any kind of wastewater treatment. The numerous "known" parameters, "known-unknowns", and "unknown-unknowns" that have to be eliminated to meet discharge standards.

The state-of-art Electro Contaminant Removal (ECR) system adopts electrocoagulation principle and is a process of removing the contaminants in water with the passage of electricity. This process destabilizes suspended, emulsified, or dissolved contaminants in an aqueous medium. The electromotive force provided drives the chemical reactions and compound will approach the most stable state. Generally, this stable state is a solid that is less colloidal, less emulsifiable, or less soluble than the element or compound at equilibrium values. As this occurs, the contaminants form hydrophobic entities such as precipitates or phase separations that can easily be removed by a number of secondary separation techniques.

ECR is proven to be the best alternative technology for Primary treatment system in wastewater treatment and re-use. This technique also serves for high-end treatment technologies like Nano Filtration, Membrane Filtration, and Reverse Osmosis.

The advantages of this system are flexibility with any kind of wastewater, smaller footprints it acquires, operating costs, volume of sludge produced and its nature over the conventional treatment methodologies. This paper attempts to focus the technology application in the wastewater treatment sector focusing on the Asian region.

Keywords: Wastewater, Contaminant Removal, State-of-art technologies, Electro Contaminant Removal (ECR), Electrocoagulation.

Introduction
Wastewater arises from both industrial and domestic activities and their Treatment, Management and Reuse are one of the key issues of the day that demands high technical know-how, energy and infrastructure to achieve a better treatment goal. Industrially discarded water is specific to the nature of industry and hence type of treatment adopted might be unique but domestic wastewater or sewerage is consistent in nature. As known, there are a lot of known and unknown contaminants in wastewater that has to be effectively removed to get good quality treated water.

Contaminant removal technologies occupy a central role in the primary treatment mechanisms of any wastewater treatment. With an efficient contaminant removal system, most of the parameters in the wastewater could be cracked.

Electro Contaminant Removal (ECR) and the Technology

Electro Contaminant Removal (ECR) or Electro Coagulation (EC), the passing of electrical current through water, has proven to be effective in the removal of contaminants from water. EC systems have been in existence for many years (Dietrich, patented 1906), using a variety of anode and cathode geometries. The flocs produced from EC process is much different from chemical coagulation from the fact that it is less bound by water and easily filterable (3).

The ECR adopting electro chemical process 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 cat-ions (2) 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 (1).

In the simplest form, a Trident ECR, Figure 1, reactor is made up of electrolytic cells with an anode and a cathode. When connected to an external power source, the anode material will electrochemically corrode due to oxidation, while the cathode becomes passive. For a workable rate of metal dissolution, electrodes with larger surface area are configured. This is achieved by using cells with electrodes either in parallel or double configuration.

The conductive metal plates are commonly known as “sacrificial electrodes”. ECR often neutralize ion and particle charges, thereby allowing contaminants to precipitate, reducing the concentration below that possible with chemical precipitation, and can replace and / or reduce the use of expensive chemical agents (metal salts, polymer). An EC process produces several distinct electrochemical results independently.

Figure 1. ECR T-5 operating at 5 cubic meters / hour

ECR -- Principal

Electro Contaminant Removal or Electro Coagulation is the process of destabilizing suspended, emulsified, or dissolved contaminants in an aqueous medium by introducing an electrical current into the medium. The electrical current provides the electromotive force to drive the chemical reactions (5). When reactions are driven or forced, the elements or compound will approach the most stable state. Generally, this stable state is a solid that is less colloidal, less emulsifiable, or less soluble than the element or compound at equilibrium values. As this occurs, the contaminants form hydrophobic entities such as precipitates or phase separations that can easily be removed by a number of secondary separation techniques.

Although the electrocoagulation mechanism resembles chemical coagulation in that the cationic species are responsible for the neutralization of surface charges, the characteristics of the Electrocoagulated flock differ drastically from those generated by chemical coagulation. An Electrocoagulated flock tends to contain less bound water, is more shear resistant, and is more readily filterable (4).

Designing ECR

Trident units operate at atmospheric pressure. The chamber can be built to meet any flow rate. However operational constraints such as the weight and size of steel play a vital role in configurations and operations. Hence, Standard flow rates are 5 cubic meters/hour, 10 cubic meters/hour, 20 cubic meters/hour, and 40 cubic meters/hr., higher flow rates are configured on a modular basis.

The ECR has the following components

- The Reaction Chamber
- The Power panel
- Plumbing

Reaction Chamber

Reaction chamber has electrodes that are placed in parallel. Depending on the nature of the incoming flow stream Mild Steel, Aluminum or both are used as electrodes. The blades at the terminals act as the power blades. The chamber can be doubled or tripled with additional power blades. The influent to be treated is introduced at the bottom of the chamber and dispersing it evenly as it moves upward through the blades. Direct Current (DC) is introduced into the chamber; the liquid then becomes a conductor, allowing the DC current to pass. The metal blades react to the current by releasing charged metal ions into the influent. The flooding of electrons in the wastewater neutralizes charged particles, causing them to be pulled out of suspension. The metal ions tend to form metal oxides that electromechanically attract to the contaminants that have been destabilized. Figure 2 shows the reaction of emitted electrons with contaminants. The Reaction Chamber includes an air purge system to keep debris from accumulating inside the chamber (6). Further, operation is optimized by controlling reaction chamber materials, amperage, voltage, flow rate, and the pH of the water. Variables such as temperature and pressure have little effect on the process, Figure 3 and Figure 4.

Figure 2. Treatment in ECR

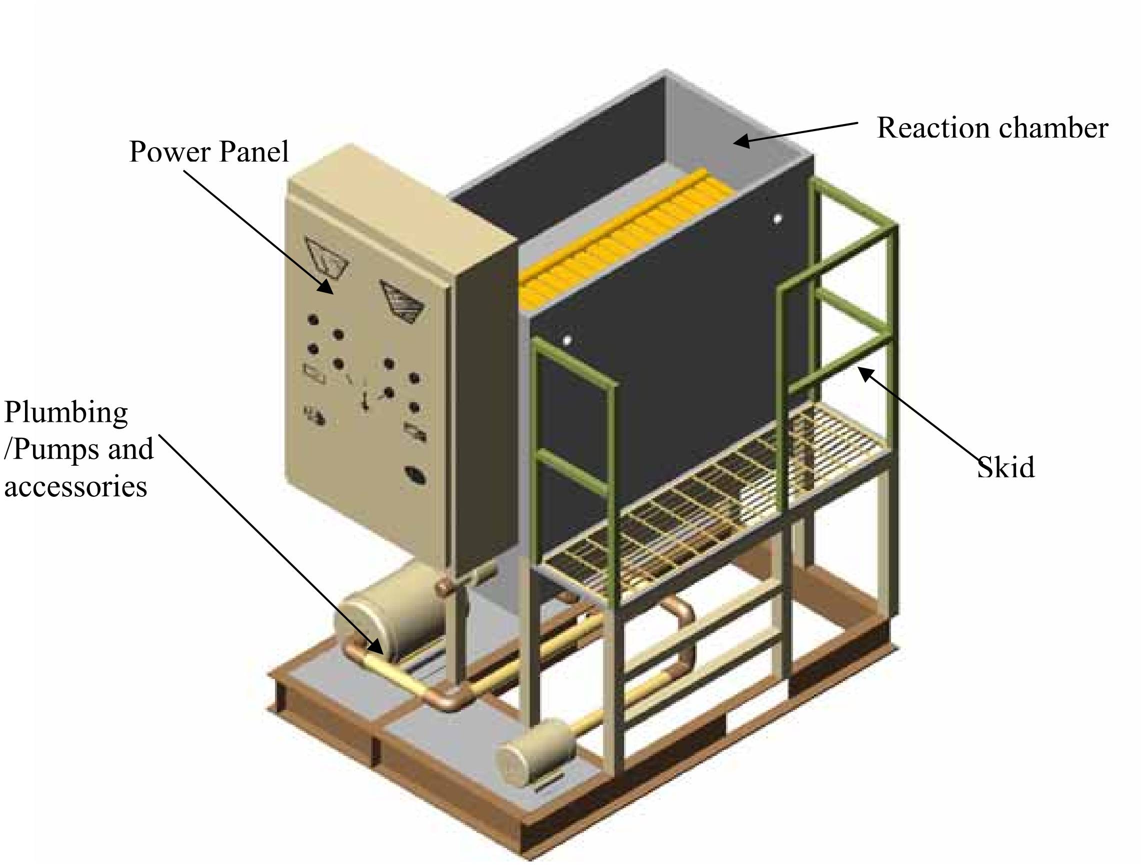

Figure 3. Typical ECR system Configuration

Power Panel
The power panel is designed to cater the power required to the chamber, pumps and other parts. Electricity enters the chamber in anode and cathode pairs. The voltage between the anode and cathode is pre-determined transforming grid power to the voltage required between the plates. The bipolar design allows line voltage to be converted from AC to DC and this saves weight and space of electrical transformers. Also allows for energy efficient power operation of 3 volts per gap between the plates, which saves amperage and eliminates the need to connect electrical conductor to each plate.

Plumbing
There is an Influent pump that pumps water to the chamber and a CIP (Clean In Place) pump that is used for intermittent acid washes of the chamber. The chamber is washed with acid to remove any adhering solids on the plates / blades.
The treated water from the chamber overflows to a weir and gravity discharges to a clarifier to remove solids.

The following table gives treatment efficiencies of ECR / Chemical Coagulation and Sedimentation.

Table 2. Comparative analysis ECR / Chemical coagulation / Sedimentation

	Percentage of removal		
Constituent	**ECR**	**Chemical**	**Sedimentation**
TSS	95 to 99%	80 to 90%	50 to 70%
BOD	50 to 98%	50 to 80%	25 to 40%
Bacteria	95 to 99%	80 to 90%	25 to 75%

Figure 5. ECR Treated water (1: Before ECR, 2: Settlement after ECR, 3: After Filtration).

2.4. Application
ECR has found a very firm position in the following industrial wastewater treatment

- Oil and Gas Exploration
- Textile Dye house wastewater treatment
- Municipal Solid Leachate treatment
- Automobile industry
- Paper and pulp industry wastewater treatment
- Food and Beverage industry

Conclusion
With the increasing threat to availability of fresh water for human needs, technologies pertaining to Contaminant Removal systems are indispensable to get better end results of treatment and re-use standards.

Developed countries still are facing water scarcities and Japan is not an exception for this. As automotive sector is one of the biggest businesses in Japan, this technology will be a definite boom to treat the wastewater released by factories. Also, this system can have its positive impacts on treating Municipal Solid Leachates, as handling these materials is becoming one of the challenges in Japan. Though there are numerous technologies that are contributing significantly towards wastewater treatments, this new technology, if implemented correctly would prove to be the best of all available methods.

Most of the engineers may not be able to predict the life of this new technology but this new concept of wastewater treatment will have its good life for the next few years especially in the regions like Asia.

"All know the Way, but few actually walk it".

References

Benefield, L. D., Judkins J. F. and Weand, B. L. 1982. Process chemistry for Water and Wastewater Treatment. Prentice – Hall Inc., p. 212

Duffey, J. G. 1983. Electrochemical Removal of Heavy Metals from Wastewater, Product Finishing, p. 72, August 1983

EPA, a SITE Superfund Innovative Technology Evaluation: EPA/640/S-937504. EPA, a SITE Superfund

Metcalf & Eddy, Wastewater Engineering Treatment Disposal Reuse, Third Edition, page 301-303

Scot Wade Powell.,Apparatus for electrocoagulation of liquids, United States of America, Patent No. 6,139,710