

Ask Tom! Column

Electro-Catalytic Oxidation of Oily-Wastewater Process Streams

Guest article by David Orlebeke, Director, Aquatic Technologies



Introduction

Standard oily-wastewater remediation relied for decades on API 650 for oily-wastewater separation (OWS) treatment using gravimetric lagoon separation, then reprocessing the recovered floatable oil portion, and using holding-pond clarification of the wastewater portion before 'land-farming' discharge, with led to substantial groundwater and air pollution. (Photo: Portable manure lagoon treatment unit, Colorado DOC.)

Gravimetric treatment and land application discharge had significant design shortcomings during routine process upsets, under-sizing for increased production, and uncontrolled storm runoff mixing with the wastewater. OWS certainly can't be expected to meet the more stringent requirements of modern environmental regulations, or be deployed for remote sites as a package treatment plant option.

Various new configurations of separation technology have expanded oily-wastewater treatment options, everything from hydro-cyclones to coalescing plate filters, dissolved air flotation and even the use of ultra-filtration to separate and concentrate the individual waste streams. While these methods offer good process response through a wide range of flows, and can meet typical 100mg/l total hydrocarbon cleanup regulations, they are incapable of meeting proposed European environmental protection legislation, and also risk non-compliance with the ATEX Directive for processes operating in explosive environments.

Moreover, none of these filtration methods offer the capability of treating the produced wastewater for heavy metals, COD, denitrification and phosphorus removal without more advanced treatment processes, such as chemical precipitation, air stripping, chemical oxidation, or activated carbon adsorption. Again, these advanced processes generally cannot be deployed for remote sites as a package treatment plant option, and all produce a toxic concentrate or sludge which then becomes another waste stream.

A number of promising techniques based on use of electrochemical technology are being developed and are already entering into industrial application. Principal among these is the Electro-Catalytic Oxidation (ECO) of oily-wastewater process streams.

Scoping Development Questions

What Is it?

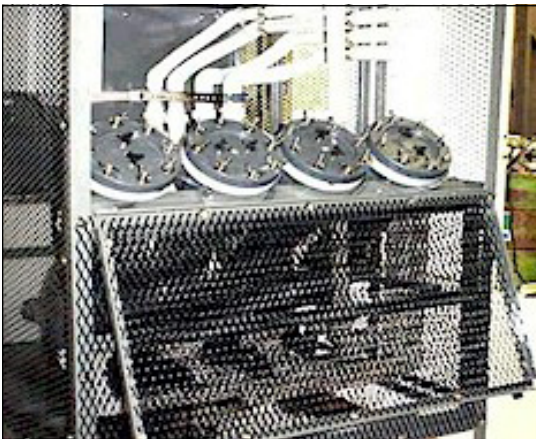
Electro-catalytic oxidation (ECO) relies on injection of suitable biological and chemical catalysts to aid further separation and coagulation of the wastewater components. The catalyzed process stream is then pumped through a venturi-eductor aeration unit, (patented by Mazzei Injector) with optional oxygen concentrator (patented by SeQual Technologies). Then the pre-catalyzed and pre-aerated process flow is subjected to a controlled direct-current (DC) electrical field within an electrode contact chamber (patented by Aquatic Technologies-brand named as the EOH₂O™ Process), similar to ordinary electrolysis, and in either a batch or a process mode.

How Does It Work?

Oily-wastewater is composed of suspended oily lipid droplets in water, interspersed with solid particles and with dissolved compounds, each having different molecular weights, chemistries and electrical charges. These electrical charges can be measured as the 'zeta potential', and tend to keep the oily lipid droplets, solid particles and dissolved compounds from interacting chemically. Electrical charges tend to form a semi-stable emulsion (similar to milk), which is difficult to separate to the level of treatment required.

However, under suitable conditions of pre-catalysis and pre-aeration, with the application of a controlled and carefully-applied DC voltage and current (patented electro-oxidation) several unique physio-chemical effects result:

1. Coalescing Super Coagulation - ECO neutralizes the charges surrounding the lipid droplets, allowing them to quickly coalesce and 'super-coagulate' out of an emulsion. This applies to both heavy- and to aromatic-hydrocarbons, with any specific results in coalescing and super-coagulating dependent on the compounds' molecular weights and their concentration in the wastewater stream;
2. Chemical Oxidation - ECO creates free hydroxyl (OH⁻) radicals in solution which rapidly and aggressively combine with, and then oxidize, oily lipids, particulates and dissolved compounds, depending on their individual chemistries.
 - 2.1 In particular, ECO has the potential to breakdown complex organic molecules, including high molecular weight compounds that may be resistant to other forms of treatment, such as pesticides, herbicides, dyes and wet-process chemicals.
 - 2.2 ECO works on many dissolved metals by forming stable metallic oxides which rapidly precipitate from solution as particles, to a high level of removal efficiency.
 - 2.3 ECO directly reduces chemical oxygen demand (COD) in many cases.
3. Biological Inactivation - ECO free hydroxyl (OH⁻) radicals rapidly and aggressively combine with and destroy bacteria, viruses, cysts, macrophages and other biological contaminants, similar to the effect of using ozone, but a level of magnitude better. Depending on water chemistry and contact time, log 5 inactivation is achievable. This biological inactivation potential is being used by the US military as a pre-treatment with reverse-osmosis (RO) to prevent biological-warfare on potable water supplies.



The entire ECO unit has no moving parts (other than catalyzing agent injection pump), and can be made highly-compact and portable as a package treatment unit, looping through a contact-holding ECO-treatment vessel, which can also be made trailerable. (Photo: Portable oil barge washout wastewater treatment unit.)

ECO has achieved previously unobtainable wastewater treatment efficiencies, short of distillation and thermal dissociation which is far more complex and expensive. In order to evaluate the applicability of ECO to a particular water or wastewater process stream, however, a thorough and detailed water chemistry must be defined, and a volume of sampling taken for bench testing to confirm theoretical prediction of treatment efficiency.

Targeting Electro-Catalytic Oxidation Applications

Water Pretreatment (Especially military and homeland defense application)

ECO is being used upstream of standard filtration units to pre-oxidize and pre-sterilize raw water, removing BOD, COD, dissolved metals and biological contaminants. ECO pre-treated water can be subjected to sand filtration, ultra-filtration, GAC and/or RO, as required for raw water conditioning necessary to meet potable water standards.

Vintner and Water Bottling Operations

ECO is being explored in the winery industry as a non-chemical treatment for stopping fermentation and for preventing bacterial growth after bottling, including cork treatment to eliminate off-flavors in wine. It can also be used in preference to ozone as a suitable non-chemical treatment for water bottling operations in some cases, much more cost-effectively, and without the attendant health-safety issues of using ozone.

Spa and Hotel Tourism Industry

ECO's unique biological inactivation capability allows it to substitute for chlorine, silver or ozone in spa water treatment. ECO pretreated water is clear, sterile and bactericidal. When used in conjunction with biological catalysts which break down sloughed skin cells and oils commonly found in spas, ECO offers a natural alternate to noxious chlorinating

Fresh-water Aquaculture

Because ECO both oxidizes the aqueous environment and at the same time destroys organic wastes and biological contaminants, it is being used successfully in fresh-water aquaculture to achieve sustained densities previously unobtainable without massive external water treatment. 1.0lb/gallon density is a sustainable EO aquaculture practice. The fish fillet end-product can be marketed as an organic food, since ECO allows fish farmers to avoid the use of pharmaceutical antibiotics for disease control.

Process WasteWater Treatment (Especially in pharmaceutical and dye industries)

ECO is being successfully tested for breakdown of complex and biologically active large organic molecules such as pesticides, herbicides, dyes and endocrine disruptors (ED's). ECO treatment end-products are small-chain, generally biologically-inert, compounds, plus carbon dioxide and water. ECO pretreated wastewater can be subjected to sand filtration, biological oxidation, ultra-filtration and GAC, as required for the conditioning necessary to meet wastewater discharge standards.

Produced Oily Wastewater Treatment (Especially in Refinery and Offshore Industries)

ECO is being successfully tested for breakdown of oilfield produced water, oily barge ballast water, drill fluids, gas and oil pipeline entrained water, and refinery process water. ECO treatment end products are coalescable and super-coagulated oils and greases, biologically-inactive compounds, carbon dioxide and water. ECO pretreated wastewater can be subjected to hydro-cyclone, skimming, foam-fractioning, and biological oxidation as required for the conditioning necessary to meet wastewater discharge standards.



Oil Barge Washout Water: beginning sample to finished sample.

Fully automated electro-catalytic oxidation treatment systems can be equipped with programmable logic control (PLC) systems that monitor, adjust, and verify the level of wastewater conversion to harmless by-products. ECO systems are designed to be portable, container-able, modular units with a minimal footprint to ease integration into existing plant layouts, or make easily field deployable units for batch site cleanups.

Because ECO now meets EU 2009 and ATEX Directive for treatment use in oil and gas environments, advanced pilot testing towards future deployment is being reviewed by:

- Varco - Drill cuttings processing
- Petrofac - Gas reception/transmission
- Enviroco - Waste management contractor
- Tayors - Waste management contractor
- BP Oil – Drilling exploration produced water
- Du Pont Global - Chemical treatment

Cost Considerations

Storage & Transportation

All components of a complete ECO system are modular and containerable. All electrical components are NEMA 4X and the units can be stored in wet environments within the same suitable limits for electronics exposure of any automated industrial equipment.

Economic Viability

Initial costs for ECO deployment will be substantially lower than for fixed treatment plant. Modules can be available for emergency deployment within 24 hours to anywhere on the globe, and set up and treating water or wastewater within a matter of hours. This ability makes ECO ideal for military and emergency application. Operating and electrical costs are substantially lower as well, since the units require minimal mechanical pumping and generally limited operating personnel attendance in automated mode. Over time, the electrodes will gradually need to be replaced, as with any electro-mechanical equipment.

Conclusion

In combination with commercial systems to prescreen raw water or wastewater, and using electro-catalytic oxidation pretreatment, followed by post-filtration and biological oxidation as applicable and cost-effective, ECO offers the potential to meet water and wastewater environmental regulations scheduled to implement in

2009 or thereabout. The applicability and cost-effectiveness of ECO, as with any water or wastewater treatment technology, can be determined following on detailed lab test characterization, bench testing and then pilot plant deployment for a suitable period of field testing

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Welcome to Ask Tom!, a monthly column by our resident water treatment guru, Tom Keenan of National Environmental Services Agency (NESA). Tom addresses the issues that bug you the most. And Tom knows!! With 35 years experience in providing environmental support services to public and private sector clients on a wide range of environmental issues.

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Guest articles for the **Ask Tom!** Column are always welcome, for more information please contact Tom Keenan directly at his email address: info@nesa.ie

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