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Direct versus indirect electrochemical oxidation of pesticide polluted drainage water containing sodium chloride

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Drainage water from a depot of chemical waste, polluted with a mixture of organophosphates and degradation products was treated by a direct as well as an indirect electrochemical method using a Ti/Pt-Ir anode and Stainless Steel 304 cathode. With a concentration of 0.7%, sodium chloride was the main electrolyte. The direct electrochemical treatment showed a first order degradation of COD with an optimal energy consumption of 110 kWh/kg COD. At constant current, addition of sodium chloride resulted in increased degradation up to 2%, whereas no further degradation was obtained at higher concentrations. Analyses of the actual pollutants, Me-Parathion, parathion, malathion and degradation products, confirmed that the concentrations of all initial pollutants were eliminated during the treatment. The only exception was O,O,O-triethyl-phosphoric acid, a degradation product which was formed during the treatment. Indirect electrochemical treatment, where a highly oxidized brine solution was added to the drainage water, revealed immediately reduction in COD, and similar to the direct treatment, degradation of all of the pesticide pollutants was obtained except for the O,O,O-triethyl-phosphoric acid.

The experiments proved that the obtained degradation of pesticide solely was caused by indirect electrochemical oxidation, mainly due to the electrolytic formation of hypochlorite during the treatment, and that direct electron transfer from the pesticide substances at the anode surface didn't significantly contribute to the degradation. Experiments with addition of aqueous sodium hypochlorite solution to the drainage water revealed that hypochlorite was the main oxidizing agent responsible for the indirect oxidation.

The experimentally obtained results for the pesticide degradation were compared to theoretic calculations of degradation rate of parathion using the actual experimental conditions and reactor design. These calculations showed that applying expressions for fractional conversion in a PFR reactor, assuming mass transfer as the limiting step, direct oxidation of the non-ionic pesticide substances due to convection and diffusion was negligible compared to electrolytic oxidation of chloride with subsequent indirect oxidation by hypochlorite due to the high impact of the electric field on the chloride ion. In this way, the theoretical calculations supported the experimental results.