ELECTROCOAGULATION FOR TOXIC METAL REMOVAL

An Effective Technology for Wastewater Treatment

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PRINCIPLE

Electrochemical coagulation is based on controlled dissolution of an iron electrode through the flow of electric current, where Fe2+ ions of the coagulating agent (green flocks) are released into the water to be treated to provide a large active surface for the adsorption or reduction of the toxic metals to be removed. Subsequently, it is necessary to bring the flocks of the coagulating agent into direct contact with the toxic metal ions. Flocks are latter oxidized from Fe2+ to Fe3+, and aggregation and sedimentation processes occur.

APPLICABILITY

The basis of the technological unit is an electrocoagulation cell with an exchangeable electrode pack with iron plates. Contaminated water flows between the iron plates. The electrode pack is connected to a DC power source with regulation up to 120 A. The amount of Fe electrochemically dosed into the water to be treated is based on Faraday's law, and usually it exceeds 4- to 5-times the toxic metal concentration. From the electrocoagulation cell (see Fig. 1), the water to be treated flows into a fast mixing tank (200 RPM), where the Fe flocks are homogeneously distributed. In the next step, water flows into a slow mixing tank (30 RPM) where the flocks are aggregated and a more compact sludge is formed, and, in the last step, gravity sedimentation of the sludge flocks takes place.

The cleaned water leaves the overflow, and the thickened sludge is further drained by a filter press or a drum sieve. According to the leachability test results, the sludge is deposited at an appropriate waste landfill.

Due to the electrocoagulation process, the electrode plates are covered with sludge

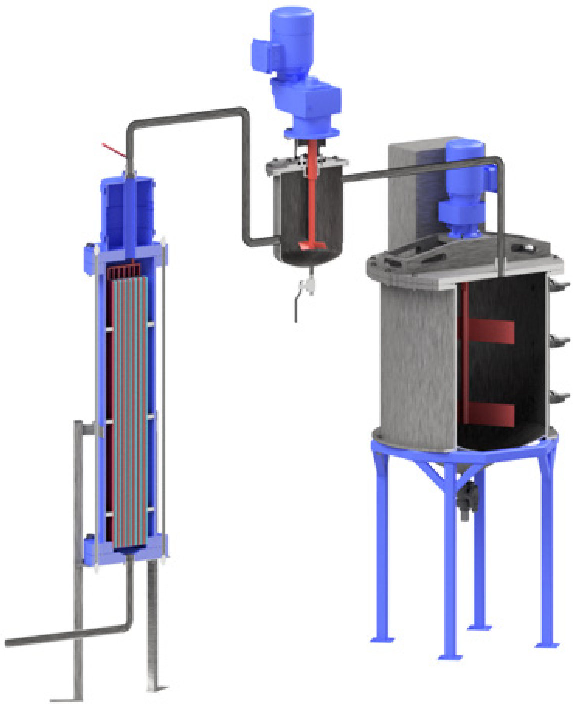


Fig. 1 Basic scheme of an electrocoagulation unit.

and iron particles and must be rinsed with pressurized water and regenerated with H_3PO_4 or HCl periodically. This operation is necessary to restore surfaces of plates. The main operating costs of electrocoagulation are represented by Fe consumption, amounting to about 0.8 - 1.5 EUR / m^3, and electricity consumption, amounting to 0.3 - 1 EUR / m^3.

Main advantages of the technology

- High efficiency of removal of toxic metals Cr^{6+},Cr, Ni, Pb, As, Al, Cu, Zn
- Precise electrochemical dosing of the coagulating agent (Fe^{2}+ flocks)
- No chemicals added
- Electrochemical conductivity does not increase
- Reduction of sludge production

Services and products

- Sampling and analysis of contaminated water
- Laboratory electrocoagulation tests of a delivered sample of water
- Verification of the electrocoagulation process on wastewater at the customer's company
- Case study and basic technological design of an electrocoagulation unit, estimate of investments and operating costs
- Provision of a full scale electrocoagulation unit for 2 m^3/hour

Potential limitations

- pH interval 4.5 – 10, iron flocks dissolve at other pH values
- Low electrical conductivity, its value must be higher than 1500 μS/m
- High concentration of toxic metals, total concentration up to 100 mg/l
- Presence of chlorinated compounds
- Presence of suspended solids or sludge

DATA NECESSARY FOR THE TECHNOLOGY DESIGN

- Types and concentrations of the wastewater contaminants (toxic metals, total organic carbon, pH, electrical conductivity)
- Wastewater input capacity needed
- Contaminant concentration limits in the cleaned water

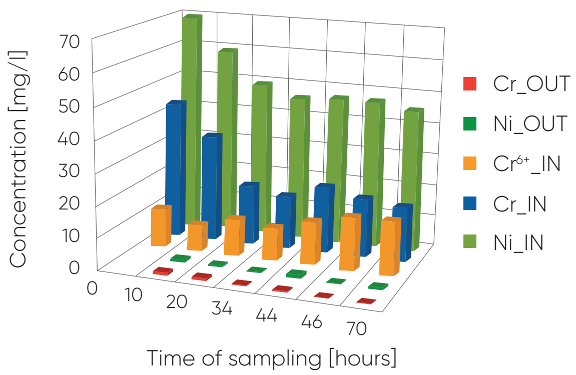
REFERENCES

The electrocoagulation process was verified as a pump & treat technique for the remediation of contaminated groundwater containing $Cr^{6}+$ and Ni, in the area of a galvanizing plant.
The contaminated groundwater (pH = 4.6, Cr = 40 mg/l (mainly Cr^{6} +), and Ni = 70 mg/l) was pumped from the well and flowed through the electrocoagulation cell at a flow rate of 250–400 l/h. Electrical current of 35 - 45 A flowed through the electrode pack and released $Fe^{2}+$ - a strongly reducing agent that immediately reduced Cr^{6+} to Cr^{3+}, according to the equation bellow.

$Cr^{2}O_7^{2-}$+ $6Fe^{2+}$ $+7H_2O \rightarrow 2Cr^{3+} + 6Fe^{3+}+14OH^-$

The output water from the electrocoagulation cell flowed through a first rapidly stirred tank and then it flowed through a slowly stirred tank, as shown in Fig.2.
Aggregation of Fe flocks in the slowly stirred tank was enhanced by a flocculant and $Ca(OH)_2$ solution dosing. Flocks of Fe sludge were settled in a sedimentation tank and average concentrations of toxic metals in the cleaned water were Cr <0.2 mg/l and Ni <0.8 mg/l and pH <9.
During the pilot test, 37 m^3 of water were cleaned and 110 kg of sludge with a dry matter content of 47 % (2.97 kg/ 1 m^3) were obtained.
Energy consumption of the electrocoagulation process was 1.3 kWh/m^3 of cleaned water.

Fig. 2 Efficiency of Cr and Ni removal in the pilot electrocoagulation test.



TECHNOLOGY APPLICABILITY

The electrocoagulation technology is designed to cleaning water contaminated with toxic metals Cr6+, Cr, Ni, Pb, As, Al, Cu, Zn, Fe, and Mn. Its advantage is a high efficiency of metal removal. Application examples: mining water, metallurgy and surface treatment of metals.

Fig. 3 Cross section of the pilot electrocoagulation cell.

CONTACTS

Volutová 2523
158 00 Prague 5
Czech Republic

HQ:
Dřetovice 109
273 42 Stehelčeves
Czech Republic

info@dekonta.cz

www.dekonta.com