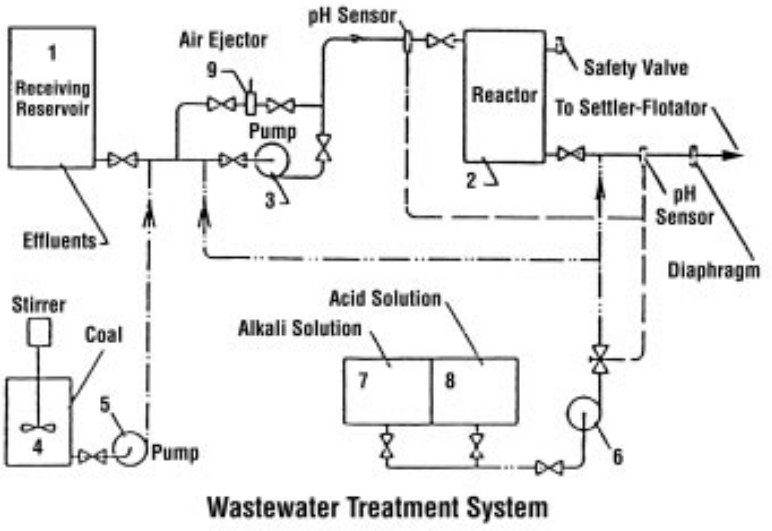
Innovative Technology for Heavy Metal Ions Removal

By S. Tamarkin

The galvano effect was used to create a new technology for treatment of wastewater contaminated by ions of heavy metals. This new technology successfully substitutes the conventional methods of treatment especially, electrochemical precipitation. For convenience, this new galvanocoagulation technology is compared with electrochemical precipitation.



Wastewater Treatment System

Electrochemical precipitation utilizes an electrolyzer (electrochemical cell) to generate hydrous iron oxide directly from steel electrodes. A DC power supply is connected between the cell's two end electrodes. As current flows from electrode to electrode through the process water, an electrochemical reaction occurs where the positively charged sides, the anodes, of the electrode give off ferrous ions. At the negative sides, the cathodes, water breaks down into hydrogen gas and hydroxyl ions. When the ferrous and hydroxide ions are added to wastewater, the chemistry is properly manipulated to provide coprecipitation and adsorption conditions capable of simultaneously removing a wide variety of heavy metals.

The galvanocoagulation technology achieves better results without application of DC power: In this case the wastewater is mixed with a solution of a special agent working as insoluble cathodes. The water is piped into a reactor loaded with particles of soluble anodes. The cathodes are made of a material that has a higher potential than the potential of the soluble anodes.

The electrodes form many galvanic couples. During this process, chemical reduction of ions of heavy metals in wastewater occurs via ions formed during electrochemical dissolution of the anodes. For example, for ions of chromium and metal anodes, the reaction is as follows:

$$Cr_2O_7^{-2} + 6Fe^{+2} + 14H^+ \rightarrow 2Cr^{+3} + 6Fe^{+3} + 7H_2O$$

$$Cr_2O_7^{-} + 6Fe(OH)_2 + 7H_2O \rightarrow 2Cr(OH)_3 + 6Fe(OH)_3 + 2OH^-$$

An example of innovative technology is described in U.S. patent number 5,658,450 is given below for treatment of wastewater from printed circuit board manufacturing and electroplating operations.

In this case, coal is selected as insoluble cathode and metal is selected as anode. As can be seen in Fig. 1, the wastewater from a receiving reservoir ***1*** is supplied by pump ***3*** into a reactor ***2***. If necessary, the pH of the wastewater is adjusted. The pH of the wastewater needs to be not less than 5 before the reactor and 7-8 after the reactor. The natural growth of pH after the reactor is 1-3.

A suspension of small particles of coal with the size of 0.5 mm and less is supplied to a suction line of the pump ***3***. The coal can be charged into a tank with a stirrer ***4*** once per shift. The suspension in the tank is prepared with the initial wastewater. The relationship between the concentration of the coal suspension (insoluble cathodes) and the degree of purification is shown in Fig. 2.

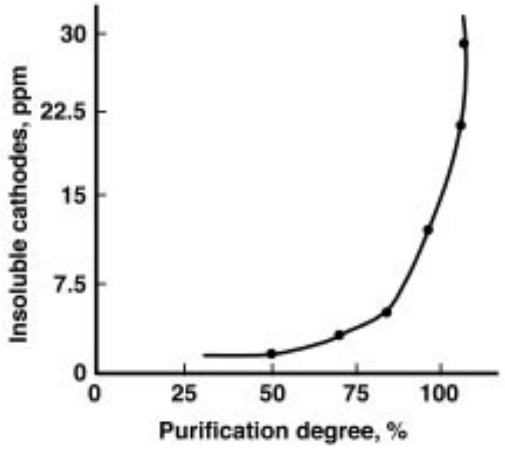
Wastewater is then passed through a reactor ***2*** loaded with particles of metal with further continuation of the process on conventional clarifiers-flotators. To remove from the wastewater 1 g of cadmium, nickel and hexavalent chromium, the consumption of metal is 3.0-6.0 g. The result of the treatment is shown in the table.

For the wastewater that additionally contains organic contamination in suspension and emulsion forms, the method described above is combined with pressure flotation. The air ejector ***9*** is installed on the pump ***3*** and a diaphragm is installed after reactor ***2***.

A diaphragm is provided to reduce pressure and to form and expand air bubbles with further continuation of the process on the clarifiers-flotators.

Two processes occur in this case, namely, saturation of the water by air with further flotation and removal of organic matter on flotators; galvanocoagulation with chemical reduction of ions of heavy metals and formation of coagulating agents that increase the effect of flotation.

	Treatment Results	
Metals	**Influent, ppm**	**Effluent, ppm**
Copper	280	0.001
Chromium^{+6}	300	0.001
Nickel	3030	0.2
Zinc	220	0.069
Aluminum	224	0.623
Cadmium	99	0.005
Cyanide (total)	26	0.98
Arsenic	700	0.01
Lead	0.8	0.0



Conclusions

The proposed technology does not require the use of electricity and appropriate equipment to convert alternating current to direct current. The application of DC power represents about 10-25 percent of the unit cost of treatment for the electrochemical cell.

The galvanocoagulation demonstrates reliable results for treatment of highly contaminated wastewater. Electrochemical precipitation is limited in this area. For example, Cr^{+6} cannot practically exceed 200 ppm in the influent.

The new technology can be used for treatment of water contaminated with heavy metals and organic contaminations that are in suspension and emulsion forms. Such contaminations at this time require separate treatment systems. Further research is needed for different combination of wastewater in this case.

The productivity of the new technology is higher than the conventional method because of the intensive electrochemical processes resulting from very large electrode surfaces and pressure conditions.

Meanwhile, the new technology keeps the advantages of electrochemical precipitation, such as low quantity of sludge production and simplicity of operation and maintenance.

Editor's note: *Manuscript received, August 1998. revision received, December 1998.*

References

1. U.S. patent 5,385,653: Method and Device for Industrial Waste Water Treatment (1995).
2. U.S. patent 5,658,450: Method and Device for Industrial Waste Water Treatment (1997).

About the Author

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Investment Spotlight

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could rise up to 10 percent against the dollar by year-end 1999.[2]

What Are the Long-term Investment Implications?

Superior Earning Momentum

This may be a more viable and vibrant economic region owing to EMU monetary, fiscal and economic reforms. The Eurozone is only one year into a business cycle recovery that may have several years yet to run with EMU as a growth "kicker." Corporate profitability may be enhanced as the cost of capital declines and companies restructure to take on a more competitive environment.

Low Interest Rate

The introduction of the Euro and a sole monetary authority could help sustain low interest and inflation rates, a longer economic cycle, and an attractive environment for stocks. The drivers here are twofold:

1. The Euro should place downward pressure on prices, and
2. A strong, independent European Central Bank (ECB) should prevent competing monetary policies by separate central banks.

Rising Appetite for Stocks

Stock yields are increasingly competitive with low and falling cash rates in many Euro markets. This should encourage individual savers to move out of bank deposits and into financial assets in increasing numbers. Here again, this is a function of the new interest rate structure ushered in by EMU, not seen this low for this long in a generation. Over time, this new class of owners of European stocks could force positive changes in shareholder returns, as it has been shown to do in the U.S and U.K.

Increased M&A/ Corporate Activity

Mergers, acquisitions, corporate buybacks and restructuring will increase. In part, lower regulatory barriers are to be credited, another hallmark of EMU as outlined above. Regulators have made it easier for Eurozone companies to buy their own stock, or buy out other firms across borders. The effect has been to promote better capital efficiency and competitiveness. Competition gets even sharper as the Euro will likely expose big regional disparities in producer and consumer prices. In this tough business environment, the urge to merge is reinforced, and for some companies, it may become a matter of survival.

EMU is not all about money, however. There are initiatives in place to standardize tax laws, workforce regulations, financial services markets, etc. The single currency, however, is what is thought to have the most far-reaching impact. P&SF

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[1]*Source: Salomon Smith Barney Research*

[2]*Source: Salomon Smith Barney Global Economics Team*