



## *Project Summary*

# **An Innovative Coprecipitation Technique for Removing Heavy Metals from Wastewater**

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This project attempts to develop innovative technology to remove toxic heavy metals from raw municipal wastewater without simultaneously removing the largely organic suspended and settleable solids. The object was to reduce the metal concentrations in the sludge produced by subsequent wastewater treatment. An upflow expanded sand bed was used with lime feed to cause coprecipitation of metals and calcium carbonate on the surfaces of sand grains. Through continuous plating of the precipitates, the sand grains increased in size and eventually formed large pebbles a few millimeters in diameter that could be easily handled in the ultimate disposal process.

Six heavy metals were selected for this study: Cd, Cr, Cu, Ni, Pb, and Zn. Metal removal efficiency was evaluated at four pH levels from 9.0 to 10.5. Other operational parameters such as reductions of chemical oxygen demand (COD), suspended solids (SS), volatile suspended solids (VSS), and total phosphorus (total-P) were also included.

The minimum pH for achieving reasonably effective coprecipitation was 9.5, but the highest efficiency was obtained at pH 10.0 to 10.5. At pH 10.5, the metal precipitator was able to remove 70% to 92% of the soluble Cd, Cu, Ni, and Pb from a spiked tap water. In municipal wastewater (where less than 10% of the metals occurred in a soluble state), the removal efficiencies were substantially reduced. For a municipal wastewater with a typically heavy metal con-

centration, the experimental precipitator was able to reduce Cd 38%, Cr 36%, Cu 44%, Ni 33%, Pb 41%, and Zn 42% at an operating pH of 10.5. The accompanying reductions for COD, SS, VSS, and total-P were 21%, 38%, 43%, and 64%, respectively.

Since the percentages of metals and SS removed were approximately the same, the hoped-for reductions in metal concentrations in sludge are unlikely to be achieved.

*This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).*

## **Introduction**

One of the major problems confronting today's wastewater treatment operation is the disposal of the treatment plant sludge in a manner that is economically acceptable and environmentally safe. If the sludge contains low levels of toxic substances, it can be disposed of by land application. In most cases, this practice is cost effective and ecologically sound because it benefits agricultural operation. But if toxic metals are present in the sludge in sufficient concentrations, the land application practice is not feasible because some toxic metals in sludge can be taken up by food crops after the sludge is applied to farmland. Thus to deal with heavy metal pollution, toxic

metals must be removed from wastewater, and accumulations of these metals must also be avoided in the sludge phase.

Chemical precipitation is currently the most common method for removing heavy metals. Though this method can remove much of the toxic metal content of the liquid waste stream, most of the removed metals become part of the wastewater sludge. Thus this approach solves only part of the toxic metal problem and creates an additional problem by increasing the metal accumulations in the sludge phase. A new technology is needed to remove metals from the liquid waste, and to prevent their accumulation in the wastewater treatment sludge.

The object of this study was to develop such a novel technology for precipitating and removing toxic metals from wastewater without simultaneously removing the organic suspended and settleable solids. This new process was intended to remove toxic metals ahead of conventional wastewater treatment, thus leaving the primary and secondary wastewater treatment sludges with lower metal contents.

### Experimental Approach

Six vertical plexiglas columns 5.7 cm in diameter and 2.1 m high with tapered conical bottoms were used as metal precipitators. The columns were divided into two parallel sets, each of which consisted of three columns connected in series for upflow operation. Each column contained 0.9 m of 40- to 100-mesh filter sand. A variable-speed pump was used to pump wastewater into the bottom of the first column in each set. The flow rate was controlled at 650 ml/min to achieve a 48% sand bed expansion. Another variable-speed pump was used to inject lime into the wastewater. In the initial process evaluation, lime was injected before the wastewater entered the bottom of the first column. But much more efficient metal removal was obtained by injection of lime directly into the fluidized sand bed, so the systems were modified accordingly. One set of columns was dosed with alkaline tap water at pH 10.5 to precoat the sand grains with calcium carbonate before metal removal studies began.

The two systems were first operated at pH 10.5 to evaluate the potential for removing soluble metals from spiked tapwater. The systems were then operated at pH 10.5 and pH 10.0 to remove largely insoluble metals from spiked, de-

gritted municipal wastewater with lime injection ahead of the first sand columns. After the lime feed was relocated within the sand beds, operation was re-evaluated on the spiked municipal wastewater at pH 10.5 and 10.0 and further evaluated at pH 9.5 and 9.0. Removals of six metals were evaluated: Cd, Cr (VI), Cu, Ni, Pb, and Zn. For wastewaters, removals of COD, SS, VSS, and total-P were also measured.

### Experimental Results

The two systems were able to remove about 70% to 90% of the soluble Cd, Cu, Ni, and Pb from the spiked tapwater. Removals of Cr and Zn were quite erratic and averaged < 30%. No consistent differences were observed between the precoat and the other system.

When lime was injected ahead of the sand beds treating wastewater, metal removals were relatively poor and quite erratic. On occasion, negative removals attributed to washout of SS occurred. After relocation of the lime feed point, metal removals were greatly improved, and negative removals no longer occurred. The data for pH 10.5 are as follows:

Parameter	% Removal
Cd . . . . .	38
Cr . . . . .	36
Cu . . . . .	44
Ni . . . . .	33
Pb . . . . .	41
Zn . . . . .	42
COD . . . . .	21
SS . . . . .	38
VSS . . . . .	43
Total-P . . . . .	64

Operation at the lower pH values generally resulted in decreased removals.

### Conclusions

This feasibility study showed that the coprecipitation process removed approximately the same percentages of both metals and SS. The desired reductions of metal concentrations in the sludge are therefore unlikely to be achieved.

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*The complete report, entitled "An Innovative Coprecipitation Technique for Removing Heavy Metals from Wastewater," (Order No. PB 82-227 240; Cost: \$10.50, subject to change) will be available only from:*

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