United States
Environmental Protection
Agency

Municipal Environmental Research
Laboratory
Cincinnati OH 45268

Research and Development

EPA-600/S2-83-020 Apr. 1983

EPA

# Project Summary

# Full-Scale Study of Sequencing Batch Reactors

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**A conventional activated-sludge system owned and operated by the town of Culver, Indiana, was converted to a two-tank sequencing batch reactor (SBR) treatment plant. The average flow during SBR operation was 1340 $m^3$/day. Loadings varied from 0.2 to 0.4 kg $BOD_5$/day per kg mixed liquor volatile suspended solids (MLVSS) on an aeration-time-adjusted basis, and the sludge age ranged between 15 and 45 days. During the first year of SBR operation (May 1980 to May 1981), the effluent $BOD_5$, SS, and phosphorus concentrations averaged less than 10, 8, and 0.5 g/$m^3$, respectively. Phosphorus was removed chemically by adding either ferric chloride or alum. Nitrogen was removed biologically, after blower malfunctions were remedied, during the late spring of 1981. Between August and December of 1981, effluent $BOD_5$, SS, and phosphorus levels were similar to those achieved during the first year; effluent ammonium and nitrite plus nitrate nitrogen concentrations were 1.1 and 1.3 g/$m^3$, respectively. Overall, 90% of the inorganic nitrogen was removed biologically. The demonstration study showed the SBR to be a viable alternative to conventional, continuous-flow, activated-sludge treatment of domestic wastewaters for $BOD_5$ and SS removal, nitrification, denitrification, and chemical precipitation of phosphorus.**

***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

Bench-scale studies of batch reactors for treatment of municipal wastewater at the University of Notre Dame had shown many benefits for the sequencing batch reactor (SBR) approach. Batch systems were employed in many cities during the early 1900's, but they fell into disfavor because of the need for manual valving changes. Using the newly developed electronic process controllers along with the batch process and automated valves seemed a logical approach to reinstituting this type of process.

The town of Culver, Indiana, agreed to convert their existing continuous-flow, activated-sludge, plant into a two-tank sequencing batch process. Retrofitting the facility was rather simple and involved coupling automatic valves and blower controls with a process controller. To account for changing water levels in the batch process, floating weirs were constructed for purified effluent removal.

## Plant Operation

The two existing aeration tanks were operated in sequence, with each tank fulfilling the various process cycles needed to accomplish the desired treatment. The cycle times were controlled by liquid-level sensors that triggered the process controller to implement valving functions. Typical cycles and times are listed in Table 1.

Each tank completes a cycle in 6 hours, and therefore over a 24-hour period, each tank performs four treatment sequences.

During FILL, the tank that has just completed IDLE receives primary effluent until some preset liquid level is reached. The REACT period furnishes dissolved oxygen for completion of the desired biological reactions. The tank

**Table 1.** *Typical Cycles and Times for Aeration Tanks*

| Cycle | Time (hours) Tank 1 | Tank 2 |
|---|---|---|
| Fill | 2.9 | 3.1 |
| React | 0.7 | 0.4 |
| Settle | 0.7 | 0.7 |
| Draw | 0.7 | 0.1 |
| Idle | 1.0 | 1.1 |
| Total | 6.0 | 6.0 |

then enters a quiescent period with no aeration to separate mixed liquor and effluent. Effluent is removed during DRAW. Waste-activated sludge is removed from the reactor during IDLE.

The second tank in an SBR process begins to fill when the first tank starts the REACT cycle. Thus one tank is always in the FILL cycle at any given instant.

## Results

During the 2-year demonstration at Culver, the SBR was operated in two phases. Phase I was to produce secondary effluent quality, and Phase II was to achieve advanced waste treatment objectives. During both phases, ferric chloride was used to keep phosphorus levels within the state-mandated limit of 1 mg/L. Results for Phase I appear in Table 2.

During Phase II, conditions conducive to nitrification and denitrification were imposed on the SBR process. Results for this advanced treatment are shown in Table 3.

## Conclusions

As a result of this demonstration, the SBR process has been shown to be a viable option for municipal wastewater treatment. The inherent flexibilty of the process allows operation to achieve effluent levels for either secondary or advanced waste treatment. The town of Culver has been so satisfied with this method of treatment that their municipal facility has continued with the SBR operation after conclusion of the demonstration project.

**Table 2.** *Phase I Secondary Effluent Quality*

| Sample Point | (mg/L) $BOD_5$ | SS | TP | $NH_4$ +N | $NO_X$-N |
|---|---|---|---|---|---|
| Raw Wastewater | 173 | 136 | 6.3 | 20 | 2.8 |
| Primary Effluent | 132 | 81 | 5.2 | 19 | 2.6 |
| SBR Final Effluent | 8 | 8 | 0.4 | 18 | 0.4 |

**Table 3.** *Phase II Advanced Treatment Quality*

| Sample Point | (mg/L) $BOD_5$ | SS | TP | $NH_4$ +N | $NO_X$-N |
|---|---|---|---|---|---|
| Raw Wastewater | 118 | 133 | 5.8 | 16.5 | 1.7 |
| Primary Effluent | 92 | 64 | 4.8 | 14.0 | 1 7 |
| SBR Final Effluent | 6 | 3 | 0.9 | 0.4 | 1.2 |

The full report was submitted in fulfillment of Grant No. R-806598 by the University of Notre Dame under the sponsorship of the U.S. Environmental Protection Agency.

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*The complete report, entitled "Full-Scale Study of Sequencing Batch Reactors," (Order No. PB 83-183 186; Cost: $11.50, subject to change) will be available only from:*
*National Technical Information Service*
*5285 Port Royal Road*
*Springfield, VA 22161*
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☆U.S. Government Printing Office: 1983-659-017/7049