- It should require less operator's time than the conventional activated sludge process.
- At flows less than 5.0 MGD, the combined system costs (capital and O & M) for SBR are expected to be lower than conventional activated sludge.
- At flows between 0.1 and 5.0 MGD, the SBR capital and O & M costs are competitive with oxidation ditch systems.
- Proper selection of aeration modes will prevent filamentous organism growth.

The potential limitations of the SBR process are:

- There is currently only one system in the U.S. with operational experience.
- Scum accumulation was a problem at Culver because the secondary clarifiers were not equipped with skimmers.
- Sequencing of multiple tanks and operating cycles may be complex; however, this was not problem at Culver where the operator reported ease of operation.

For additional information contact:

EPA-OWPO(WH-547)
401 M Street, SW
Washington, DC 20460
(202)382-7370/7369

EPA Region 1
John F. Kennedy Federal Building
Boston, MA 02203

EPA Region 2
26 Federal Plaza
New York, NY 10278

EPA Region 3
6th & Walnut Streets
Philadelphia, PA 19106

EPA Region 4
345 Courtland Street, NE
Atlanta, GA 30308

EPA Region 5
230 South Dearborne Street
Chicago, IL 60604

EPA-MERL (489)
26 West St. Clair Street
Cincinnati, OH 45268
(513)684-7614

EPA Region 6
1201 Elm Street
Dallas, TX 75270

EPA Region 7
324 East 11th Street
Kansas City, MO 64106

EPA Region 8
1860 Lincoln Street
Denver, CO 80203

EPA Region 9
215 Fremont Street
San Francisco, CA 94105

EPA Region 10
1200 6th Avenue
Seattle, WA 98101

United States
Environmental Protection
Agency

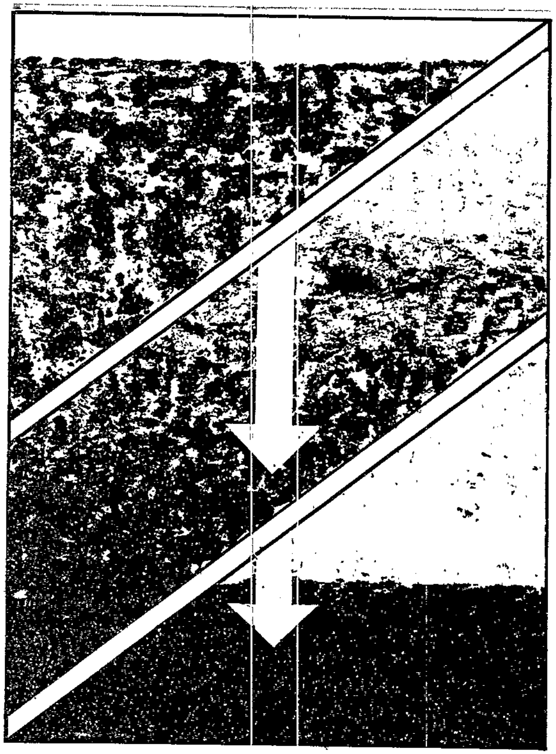
September
1983

EPA

An Emerging Technology

Sequencing Batch Reactors

A Project Assessment



Sequencing Batch Reactors - A Project Assessment of

Background

Cost considerations are playing an increasingly important role in a community's selection of a wastewater treatment technology. For this reason, consulting engineers are seeking innovative ways to reduce both capital and operation and maintenance expenses to meet their client's needs. One such technology worthy of consideration is the Sequencing Batch Reactor (SBR). The purpose of this fact sheet is to introduce this technology to potential users.

Batch treatment utilizing activated sludge is not new. The first activated sludge batch systems were developed and patented in the early 1900s. However, lack of convenient and effective control systems rather than process-related deficiencies limited their use. Only recent developments in hardware such as electronic and mechanical timers, solenoids, and microprocessors have overcome these problems and rendered this technology a viable candidate for the treatment of municipal wastewaters.

The Process

SBR technology is the treatment of wastewater on a batch basis and is no more than an activated sludge system which operates in time rather than in space, i.e., all steps of the process take place, one after the other, in the same tank instead of moving to a second tank for the continuation of the treatment. Typical SBR operation (Figure 1) involves filling a tank with raw wastewater or primary effluent, aerating the wastewater to convert the organics into microbial mass, providing a period for settling, discharging the treated effluent, and a period identified as IDLE that represents the time after discharging the tank and before refilling. For most projects, a multiple tank system is required. This configuration allows incoming flow to be switched to one tank while the other is going through the aeration, clarification, and discharge functions. A key element in the SBR process is that a tank is never completely emptied, but rather a portion of settled solids is left in the tank for the next cycle. The remaining portion of this residue (sludge) is wasted. The fraction wasted will depend upon the desired sludge age.

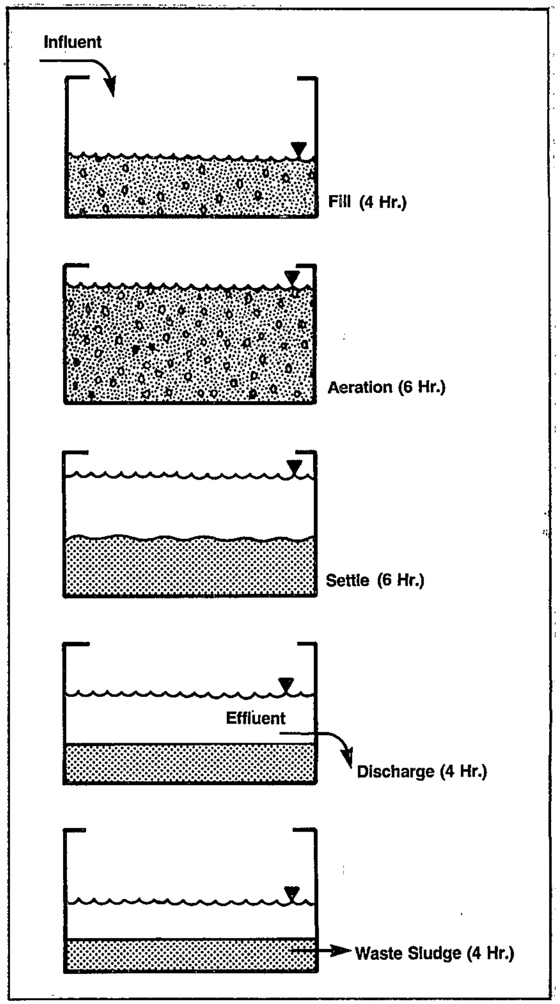


Figure 1 Typical SBR Operation for One Cycle

The retention of sludge within the tank establishes a population of microorganisms uniquely suited to treating the waste. During the process, the microorganisms are subject to periods of high and low oxygen and high and low food availability. This condition develops a population of organisms which is very efficient at treating the particular wastewater. This selection process is similar to that found in staged reactor activated sludge systems.

Demonstration Plant

An existing continuous-flow activated sludge treatment plant owned and operated by the town of Culver, Indiana was selected by the U.S. Environmental Protection Agency as the first full-scale demonstration site for SBR technology beginning in 1979. The retrofit plant in Culver is the only SBR plant currently treating domestic wastewater in the United States. The demonstration project was operated by the town of Culver in cooperative agreement with the University of Notre Dame. Other SBR projects are in design or construction phases in Grundy Center, Iowa; Sabula, Iowa; LeClaire, Iowa; and Poolesville, Maryland.

The Culver plant serves a population of approximately 2,500 people. Flow to the plant is typically 0.3 to 0.4 MGD; however, infiltration to the sewers causes occasional periods of high flows (0.8 to 0.9 MGD). A simplified flow schematic of the Culver plant is shown in Figure 2. Raw wastewater passes through a bar screen, comminuter, grit chamber, and a primary clarifier. Two aeration tanks were converted to SBR reactors. The existing secondary clarifiers were not required for SBR operation. The existing chlorine contact tank was replaced by a specially designed chlorination box for disinfection of the treated effluent prior to discharge to a stream. While the SBR at Culver treated primary effluent, raw wastewater can be treated directly in the SBR.

Operating experiences for the Culver SBR system have shown it to provide very good removal efficiencies for BOD and suspended solids. Performance data are summarized in Table 1. When operated to achieve biological nitrogen removal, the SBR system removed approximately 90% of the influent inorganic nitrogen.

At Culver, phosphorus was removed chemically by adding either alum or ferric chloride. The system at Culver was not stressed with respect to organic loading and as a result, the organic removal limitation for the SBR was not determined. The amount of time that the SBR operates in a mixing

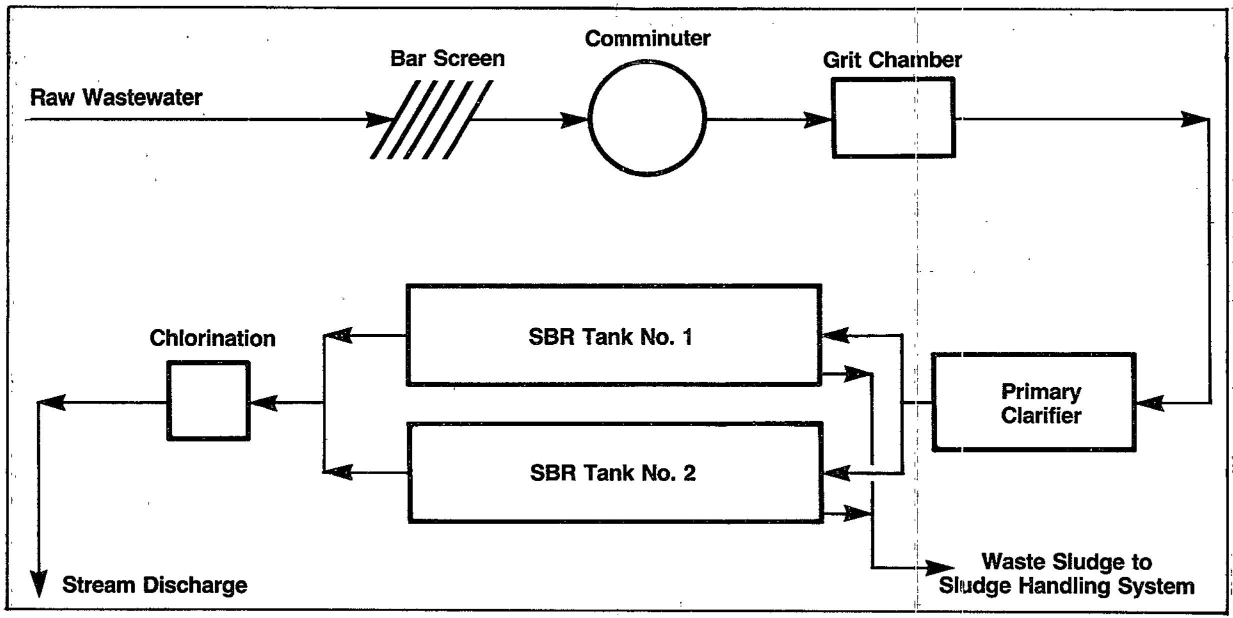


Figure 2 Culver Plant Flow Schematic

	Raw Wastewater (mg/l)	Final Effluent (mg/l)	Percent Removal
Operational Strategy: BOD removal			
BOD_5	160	9.5	94
TSS	130	8.0	94
NH_4-N plus NO_x-N	24.4	16.6	32
TP	6.3	0.45	93
Operational Strategy: Nutrient Removal			
BOD_5	170	10.5	94
TSS	150	5.5	96
NH_4-N plus NO_x-N	22	2.4	89
TP	6.5	0.75	88

Table 1 Performance Data

mode or aeration mode is more important to system design and operation than either sludge age or loading.

Cost Comparisons - Capital

Based on current projections (1983 dollars), SBR capital costs are estimated to parallel closely the capital costs for oxidation ditch systems in the 0.1 to 5.0 MGD range. Between flows of 0.5 to 5.0 MGD the SBR capital costs are lower than the costs for conventional activated sludge. These comparisons are summarized in Figure 3. The data was generated via EPA's Computer Assisted Procedures for the Design and Evaluation of Wastewater Treatment Facilities (CAPDET) program.

Operation & Maintenance

Computer estimates show the SBR process to have O & M costs equivalent to oxidation ditch systems between flows of 0.1 to 5.0 MGD. These same estimates show the SBR to have lower O & M costs than activated sludge between flows of 0.5 to 5.0 MGD (see Figure 3). This data was also generated via EPA's CAPDET program. Operating the SBR under a nutrient removal strategy would

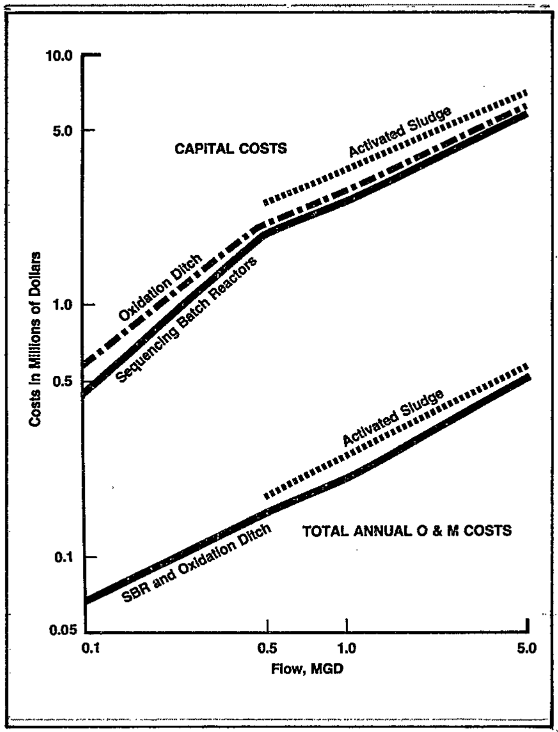


Figure 3 Cost Comparison Curves

require more energy because of the higher dissolved oxygen needed for nitrification vs. organics removal only. These increased energy requirements would lead to higher O&M costs for the SBR as well as other conventional activated sludge systems.

Summary

The SBR process offers the following advantages:

- It has the flexibility to be operated either as a labor-intensive, low energy, high sludge yield system, or as a minimal labor, high energy, low sludge yield system.
- It is well suited for systems with a wide range of flow and/or organic loadings.
- It can achieve high BOD and suspended solids reductions and can be operated with or without nutrient removal.