United States
Environmental Protection
Agency

Municipal Environmental Research
Laboratory
Cincinnati OH 45268

Research and Development

EPA-600/S2-82-050 August 1982

EPA

Project Summary

Evaluation and Documentation of the Effects of Operation and Maintenance Practices on the Performance of Selected Biological Treatment Plants

Albert C. Gray, Jr., Paul E. Paul, and Hugh D. Roberts

Recognizing the significance of the noncompliance problem and the ineffectiveness of the current federal enforcement programs, the Office of Research and Development, U.S. Environmental Protection Agency (EPA), undertook a comprehensive national study of publicly owned municipal treatment plants in 1975. This study was to identify and quantify the specific causes of inadequate performance and to formulate recommendations for improvement. Corollary objectives of the study were to identify future research needs and to demonstrate methods of improved performance.

The full report deals with the second phase of the two-part study; the findings of the first phase were published in EPA reports 600/2-79-078 and 600/2-79-034. Conclusions and recommendations of the second phase were based on comprehensive evaluations conducted at 23 treatment facilities. Of 70 potential problem areas evaluated, the 10 highest ranked, based on frequency of occurrence and severity of impact, were operator application of concepts and testing to process control, sludge wasting and return, process control testing, process controllability, technical guidance for process control adjustments, industrial loading, sewage treatment understanding, adequacy of O&M manual, training, and infiltration/inflow.

In a critical evaluation of the data, it was noted that at each treatment facility a combination of factors limiting performance was always observed and that a single cause of poor performance at any one facility was never observed. Because there is an interrelationship between performance limiting factors and corrective programs, and because most existing correction programs focus on single problems only, a new approach that addresses all problems at a single facility was developed as more effective in improving existing plant performance. This approach is called a Composite Correction Program (CCP). The purpose of the CCP is to eliminate all the performance limiting factors at a plant through the implementation of the correction recommendations that are

made as a part of the comprehensive evaluation.

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

Significant potential exists for improving the performance of biological treatment systems simply and inexpensively by upgrading operation and maintenance programs, improving attention to management and administrative requirements, and by making low-cost correction of design deficiencies.

In this research effort to identify and quantify specific cause and effect relationships in problems of performance, operation, and maintenance of biologial wastewater treatment plants, data from selected operating plants were collected and analyzed. The purpose was to identify deficiencies that caused poor plant performance; to weigh and rank, in order of severity of impact, the causative factors of poor performance at each facility; and to demonstrate on a limited basis the improvement in plant performance that can be achieved without major capital improvement when all limiting factors are corrected.

Selection of Plants

The 69 plants selected for study met the following selection screening criteria:

1. Plants must incorporate a biological treatment process as the basic method of wastewater treatment.
2. Plants should have a history of inadequate performance as measured by effluent quality.
3. Though not restrictive, hydraulic capacities of plants should range from 1 to 5 mgd.
4. Plants should not be hydraulically or organically overloaded to any great extent.
5. No enforcement action should be underway against the municipality or authority involved, nor should the municipality be in the process of designing or constructing physical modifications in the treatment facility.

During site visits to each plant, various preliminary data were compiled: process schematics, wastewater characteristics, staffing, laboratory capabilities, permit requirements, and maintenance activities. Through interviews, information was solicited from the plant staff relative to specific problems interfering with plant performance.

Site Visit Results

Observations resulting from the site visits are based on a wide data base with limited depth of detail.

1. Most plants were constructed or upgraded since 1965. As such, age of the facility or equipment was rarely cited as a problem.
2. Preliminary treatment processes were provided at 70 percent of the plants. More than 75 percent of the facilities were equipped with a primary treatment stage. Only about 15 percent of the plants, however, included a form of tertiary treatment.
3. One-third of the plants reported major problems resulting from infiltration/inflow, primarily those associated with periodic hydraulic overloads of plant units and "washout" of suspended growth biological systems. Dilution of wastewater strength and resulting upset of the biological process was also a consequence of this problem.
4. Approximately 35 percent of the plants were faced with moderate to severe problems concerning industrial wastewater discharges. Specifically, intermittent or slug organic loads from industry caused process upsets.
5. Most plants were staffed 40 to 60 hours per week. The extent of shift coverage appears to be proportional to the size of the facility.
6. Staff training at a majority of the plants was believed to be adequate on the basis of discussions with the plant operators.
7. More than 85 percent of the plants reported minimal or no downtime as a result of inadequate maintenance. An adequate on-hand supply of spare parts was reported in only about one-third of the plants, although parts were usually readily available from local suppliers.

On the basis of the site visits, 23 plants were selected for more comprehensive study to examine, in detail, the system and unit process performance and to evaluate existing operation, maintenance, and administrative practices. In all, 70 potential problem areas were addressed at each facility including plant and unit process performance, design adequacy, operation and maintenance practices, and administrative policies.

To quantify and report the deficiencies and problems at plant sites, both individually and collectively, a plant evaluation summary was developed, consisting of a weighing scale and a ranking table. The scale was devised to rank the 70 different factors that could limit plant performance. For each factor identified at a facility, the extent to which it adversely affected plant performance was quantified according to the weighing scale points. The factors affecting plant peformance were then ranked in decreasing order of severity.

Causes of Poor Plant Performance

The 10 most significant problems for the 23 plants are listed in decreasing order of severity:

1. Operator application of concepts and testing to process control
2. Sludge wasting and return
3. Process control testing
4. Process controllability
5. Technical guidance for process control adjustments
6. Industrial loading
7. Sewage treatment understanding
8. O&M manual adequacy
9. Training
10. Infiltration/inflow

The predominant factor adversely impacting plant performance is the lack of application of process control techniques. A partial cause of this situation appears to be the inability of the operators to relate generalized classroom training to their specific facility. Another reason is that the operators are not always willing to accept the merits of process control and, as a result, downplay the need for process monitoring. In many cases, the lack of a comprehensive O&M manual was determined to be a major deficiency contributing to the process control problem and limiting the operator's ability to respond to "trouble" situations, such as process upsets.

Plant design problems, such as inadequate provision for process controllability or flexibility and sludge handling limitations, hamper the efforts of the operators to practice effective process control. External factors, including industrial loading and infiltration/inflow, also adversely affect performance.

For the most part, maintenance practices at the 23 plants were satisfactory. Supervisory operators seemed to give first priority to keeping the plant equipment operating and maintaining good housekeeping practices; biological process control and optimizing plant performance as measured by effluent quality received secondary consideration.

With respect to administrative policies, two areas were examined in detail—staffing and budgeting. Approximately one-third of the preliminary evaluation plants were staffed at a level at least 25 percent less than that recommended in EPA's staffing guidelines. Examination of the O&M budgets indicates that a majority of the plants were allocated funds in excess of the average expeditures at a representative sampling of similar plants in their respective geographical areas. Therefore, budgets were not believed to be a major direct constraint on plant performance.

Improving Plant Performance Through a Composite Correction Program

An evaluation of data indicates that a combination of factors limited performance and that a single cause of poor performance at any one facility was never observed. Because there is an interrelationship between performance-limiting factors and corrective programs and because most existing correction programs focus on single problems only, a new approach that addresses all problems at a single facility is proposed as a more effective approach in improving existing plant performance. The purpose of this approach (a CCP) is to eliminate all the performance-limiting factors at a plant by implementing the correction recommendations made in the comprehensive evaluation report.

As a part of each evaluation, specific recommendations were made for improving plant performance chiefly through nonstructural modifications such as training, process monitoring and control, O&M manual preparation, staffing, and budgeting for plant operations. The actual, long-term impact of implementing these recommendations is not known. On the basis of engineering judgment, however, attainable effluent wastewater quality at each plant was estimated. On the basis of these estimates, compliance with NPDES permit limitations by the plants would improve from 55 to 86 percent for BOD_5 and from 64 to 95 percent for suspended solids, solely as a result of implementing the recommended operational improvements.

A final and important conclusion of this study relates to the cost effectiveness of implementing a CCP to improve operation and maintenance and, thereby, upgrade plant performance. Based on estimates of costs associated with implementing comprehensive evaluation recommendations at three typical facilities, initial-year costs could be expected to range from approximately $10,000 to $50,000 and annual recurring costs would range from $2,000 to $10,000. These cost estimates are given only to illustrate the order of magnitude of costs associated with a CCP. Each case will be unique in its scope and required expenditures.

Considering the benefits of improved plant efficiency and better effluent quality to be gained, the costs of a CCP appear justifiable when compared with the total investment already made in construction and operation of these treatment plants. A CCP is also a cost effective way to attain quality effluent by optimizing operations rather than achieving permit compliance through other means such as costly construction or adding capital equipment. In fact, court imposed fines for noncompliance would most likely exceed the entire cost of a CCP.

Conclusions and Recommendations

The following conclusions and specific recommendations are made as a result of this study:

1. Because operator training programs and manuals appear to have minimal impact on ensuring proper plant operation, federal and state training programs and literature should be redeveloped to relate theoretical consideration to practical operational situations and to present solutions to specific on-site problems as they arise. Manuals must reflect the input of the plant operations staff and should be easy to follow so they will be used on a day-to-day basis.
2. At the facility planning and design stages, plant design, operability, and flexibility should be subject to a specific design and O&M review as a grant-funding requirement. Such a review would serve to:
   a. emphasize the need for adequate sludge handling in small plants and design, operation, and management of existing facilities at large plants;
   b. ensure proper design of secondary clarifiers to eliminate short circuiting and ensure uniform velocity gradients in the sludge blanket;
   c. implement more rational design requirements for fixed-film biological reactors;
   d. allow and encourage separate treatment of anaerobic digester supernatant or require the size of the wastewater treatment process unit to be increased to adequately receive and treat this recycle flow;
   e. encourage plant flexibility—this would allow by-passing of ponds following mechanical plants and activated sludge plants to operate in various modes; and
   f. emphasize good controllability of return activated sludge flows.
3. To ensure that process control is practiced at treatment facilities, the following action should be taken.
   a. Improve training for private and governmental persons who provide technical operating assistance. Training must include on-site process control experience at various wastewater treatment facilities so the instructor can properly apply wastewater treatment concepts to process control. Plant design engineers should be trained in plant operations and process control.
   b. Provide operators with comprehensive and understandable process control information in the plant operation and maintenance manual; this manual, in turn, should reference other manuals that would augment and clarify theory, as necessary.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1982 - 559-017/0753

c. Hold persons who provide technical guidance on operations accountable for their recommendations. As a minimum, these people should use follow-up phone calls or plant visits to determine if the recommendations given are satisfactory and still apply.

4. Studies to determine the sources of plant performance problems should be comprehensive so that subtle as well as obvious factors that limit performance are identified. Plant administrators should become familiar with the CCP approach to improving plant performance as an alternative to making major plant modifications.
5. Federal and state regulatory efforts should be directed toward enforcement and accountability, specifically to:
   a. Expand enforcement of National Pollutant Discharge Elimination System permits to encourage optimum performance from existing facilities.
   b. Require that CCP's be implemented before planning construction of new or modified facilities to ensure that existing facilities' capabilities have been examined and optimized.
6. Budgeting for operation and maintenance of wastewater treatment facilities must be made needs-sensitive. The municipal budget must place a high priority on the dollar needs of wastewater treatment.

The full report was submitted under Contract No. 68-03-2571 by Gannett Fleming Corddry and Carpenter under the sponsorship of the U.S. Environmental Protection Agency.

Albert C. Gray, Jr., Paul E. Paul, and Hugh D. Roberts are with Gannett Fleming Corddry and Carpenter, Inc., Harrisburg, PA 17105.
***Francis L. Evans, III,** is the EPA Project Officer (see below).*
The complete report, entitled "Evaluation and Documentation of the Effects of Operation and Maintenance Practices on the Performance of Selected Biological Treatment Plants," (Order No. PB 82-227 513; Cost: $10.50, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Municipal Environmental Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268