Benchmarking – an approach to efficiency enhancement in planning, construction and operation of wastewater treatment plants

J. Stemplewski, A. Schulz and J. Schön

Emschergenossenschaft/Lippeverband Kronprinzenstraße 24, 45128 Essen, Germany

Abstract In the following paper the technique of benchmarking was transferred to the field of wastewater treatment. The method was developed within a pilot project, in which 4 wastewater treatment plants (WWTP) (size category: 10,000–100,000 p. e.) of the Emschergenossenschaft/Lippeverband and the Aggerverband were involved. Meanwhile this method is applied to more than 100 WWTP. Specific technical and economic parameters were determined for the whole treatment plant and afterwards assigned to the different treatment steps. With these numbers differences between the examined plants and the respective benchmarks were visible. On the basis of the following cause analysis a schedule could be developed containing at first measures, which could be translated into action immediately. The less obvious reasons for differences between individual numbers required a deeper cause analysis. Because of external influences not all the plants can reach the benchmarks.

Keywords Application; benchmarking; cost efficiency; wastewater treatment

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Introduction

The issue of fees and contributions has been a subject of discussion with respect to wastewater treatment facilities as well for some time. Today, increasing emphasis is placed on the aspects of economy and customer-orientation in wastewater disposal and treatment operations. This means that wastewater treatment facilities must be run as corporate entities according to sound business principles and that appropriate controlling instruments must be applied in the process.

Benchmarking is one of many instruments which could be used. The term refers to a continuous process developed and recognised in the private sector for the purpose of identifying and assessing potentials for greater economy in corporate organisations and applying the results in practice. This approach uses benchmark comparison as a tool. The following remarks pertain to projects in the field of wastewater treatment in which our organisation EG/LV is currently involved.

Benchmarking practice

The comparative approach presupposes the subdivision of one or more corporate entities into processes. Parameters are determined for each of these processes. After benchmarks have been defined, discrepancies between the parameter values and the benchmark values are determined. The goal then is to analyse the causes of the discrepancies detected, to plot a feasible course for improvement and to develop a schedule of measures for pursuing that course.

Thus benchmarking goes beyond the scope of corporate accounting. It combines business and technical principles and know-how and applies these in concrete plans of action dedicated to enhancing efficiency and cutting costs. In order to ensure success in benchmarking, the following points must be observed:

1. openness and honesty in dealing with benchmarking partners with respect to data and information;

2. openess with respect to discrepancies; in other words, no justification of discrepancies but instead identification of benchmarks, analysis of causes and development of a schedule of measures for improvement;
3. intensive co-operation between engineers and business specialists and thus total integration of corporate know-how.

Pilot project

The wastewater treatment field is selected as the first project because:

1. wastewater treatment plants in our associations represent the highest volumes in both capital investment and operating costs, and
2. information based upon experience is already available in the international context, i.e. particularly from the US, England and the Netherlands.

The objective of a second phase was to decide whether benchmarking was to be carried out internally or externally – i.e. in co-operation with another operator or a private organisation. The disadvantage of internal benchmarking is that benchmarks can be determined on the basis of a very limited sample only. For this reason, the decision was made to find a partner willing to work with this modern management tool and to disclose the data expressing the processes of its wastewater treatment plants. At this point it should be noted that, at the time the project was launched in late 1996, a comparative approach of this kind was entirely new in the field of wastewater management in Germany, although it had already been employed in foreign countries. At that time, only the Aggerverband was prepared to undertake such a comparison in the state of Nordrhein-Westfalen. In order to incorporate experience gained in benchmarking in the private sector into the comparison and thus to "learn from the best" even at this stage, the services of the Rinke-Treuhandgruppe, a corporate consulting company with experience in the field, were engaged.

To ensure that a sufficient number of wastewater treatment plants would be available for selection we agreed to focus upon plants in size category four (10,000–100,000 p.e.), from which each association was to select 2 plants from within its region. The criteria for selection were the following:

1. One "good" and one "less good" plant were to be selected on the basis of assessments current at the time.
2. Both business and technical data on the plants in question were to be easily determinable.
3. Plant employees were to be open to the project.

In addition to belonging to the same size category, these plants also shared the following characteristics:

1. they were designed for compliance with minimum requirements,
2. they were equipped with separate digestion facilities, and
3. no major investment requirements were anticipated for the ensuing five years.

In addition, project efforts were to be restricted to wastewater treatment to include digestion and subsequent concentration (if applicable), as subsequent sludge treatment/processing was conducted by the Lippeverband at other locations within the association.

These remarks clearly indicate that a number of secondary factors had to be taken into account in comparing wastewater treatment plants. This should not be taken to suggest that comparability was not possible from the outset. The restrictive specifications listed above served the sole purpose of ensuring that the project would not be overburdened with special problems from the start. In the course of the project, however, it became clear that it was not absolutely necessary to make such assumptions within the context of the model we developed in order to determine whether a specific plant had been planned, constructed and previously operated economically. Standardised performance specifications for wastewater treatment plants played a significant role in establishing comparability. These cannot be developed on the basis of a single maximum parameter value. Instead, a set of several different values is always needed. This group of values must reflect both technical and economic aspects and provide the basis for reliable statements of relevance to control measures. There is a fundamental risk that this set of values can reach a magnitude in the three-figure range, as it is considered important to represent all aspects in detail. Therefore, it was essential to ensure effective limitations of scope even during the data acquisition phase.

The benchmarking system for wastewater treatment plants was developed in keeping with these principles. This meant that the project would be applied at more than 70 wastewater treatment plants within the regions covered by the Emschergenossenschaft and the Lippeverband alone. This could only succeed if the statistical material remained manageable in scope. For this reason, a profile was developed for each wastewater treatment plant. The profile contains a brief description of the essential parameters, processes, general conditions and particularities of each wastewater treatment plant. The characteristic economic and technical parameters to be determined were then defined for each plant as a whole. The next step involved the separated calculation of these parameters for the following phases:

1. mechanical treatment
2. biological treatment
3. subsequent treatment phases
4. sludge treatment
5. operating buildings, outdoor facilities.

This paved the way for a systematic approach through which wastewater treatment plants could be subdivided into five process phases, to which five or six cost categories were then assigned. This is a process that could be carried out with a reasonable level of expense and effort. With regard to the distribution of total costs to the individual process phases it can be stated that it was possible to assign two thirds of these costs ad hoc without additional effort. Consequently, a high degree of reliability was guaranteed.

In order to establish an initial overview of noteworthy aspects, the percentage ratios of the individual cost categories to total costs were calculated in the economic segment and the percentage ratios of the process phases to the process as a whole were determined in the technical segment (Figure 1). The proportional shares of the respective process with respect to the process as a whole were identified, and first discrepancies and additional questions requiring clarification were established.

Thus it was necessary, for example, to agree upon a uniform interest rate for capital services. In addition, depreciation had to be determined on the basis of time values for new procurement in order to take proper account of differences in the age of the different plants.

Standard depreciation periods were selected for both associations. It was also necessary to consider the extent to which energy costs could be compared. In the interest of simplicity, the external reference price was used for energy production at each plant (gas utilisation). Meanwhile work is nearly finished to determine the costs of plant production.

On the basis of the characteristic values determined, a group of approximately 20 core values was selected for use in estimating the cost-effectiveness of a given wastewater treatment plant. The best of these values were then defined as benchmarks.

In the course of the ensuing cause-analysis process it became clear that the discrepancies between benchmark and actual values were comprised of two components in most cases. The first component consisted of easily explainable discrepancies from which appropriate measures could be derived immediately. The other values required more rigorous analysis and were referred to as presumed potential – presumed, because, despite the considerable

Survey of type of costs	Absolute value of type of cost	Percentages of costs
Material		26 %
of that energy-water-long-distance heating		7 %
Wages / Salaries		23 %
Depreciation		42 %
Expenditures		9 %
Total		= 100 %

Process part	Costs of process part	Costs of the process part percentage of the total costs
Mechanical Treatment	198.156 DM	21 %
Biological Treatment	241.296 DM	26 %
Sludge Treatment	133.490 DM	14 %
Et cetera (Buildings ...)	195.808 DM	21 %
Not allocated	156.054 DM	18 %
Total	924.804 DM	= 100 %

Figure 1 Extract of the specification of a treatment plant, example

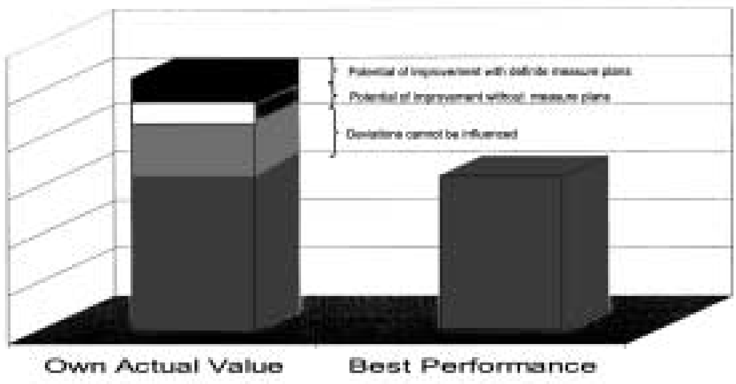

Figure 2 Analysis of the theoretical potential of improvement

effort expended, external factors make it impossible for every plant to achieve or exceed the benchmark value.

In some cases, the measures derived can be implemented immediately; in others, a more thorough analysis of plant organisation may be required. Thus, for example, the question "to make or to buy" was discussed openly within the context of the benchmarking process. The point of departure for this discussion was the fact that some plants had higher personnel costs than others but also had lower costs for services rendered. The explanation for this is that in the one case plant maintenance work is performed by plant staff, while in another case such services were performed by outside providers. Altogether, the plants had approximately the same maintenance costs. Figure 3 shows an extract of the results list of the pilot project.

Research and development

In support of a sound application of the systematic approach to all plants belonging to the Emschergenossenschaft/Lippeverband and the Aggerverband, we participated in a

	Type of costs	Distinctive classification number	Unit of classification number	Name of the distinctive plant	Distinctive value	Medium value	Minimum value	Possible reason	Result of cause analysis	Measures
1	Fuel	Fuel/people equivalent	DM/people equivalent		3.4	1.2	0.05	Is additional fueling of CHPnecessary? Increased energy requirement for pressing air through aerator	The cause has been verified	Measures have been instructed
2	Costs for staff	Staff costs/ people equivalent	DM/people equivalent		23.83	16.54	8.74	Intensive service of gas engines on the plant	The cause has been verified	1. Efficiency analysis for evaluation of success of an investment 2. Testing of hypothesis: service on site more efficient than exter-nal service (includes travelling expenses)
3	Total expenditure	Total expenditure/ people equivalent	DM/people equivalent		103.23	83.88	59.96	Maintenance of unused tanks for operation	The investment itself seems to be the main reason and not the work, which comes up for maintenance	After checking parts not required will be used at other places
4	…	…	…	…	…	…	…	…	…	…

Figure 3 Cause analysis, example

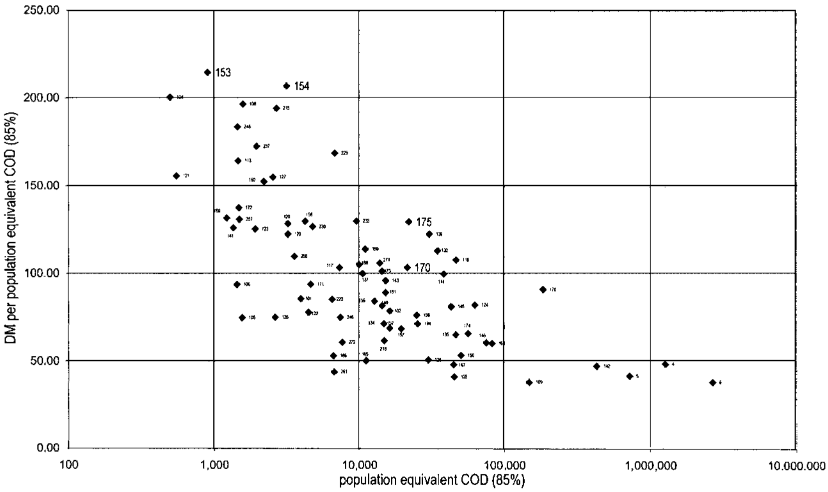

Figure 4 Standardised annual total costs per population equivalent COD (85%)

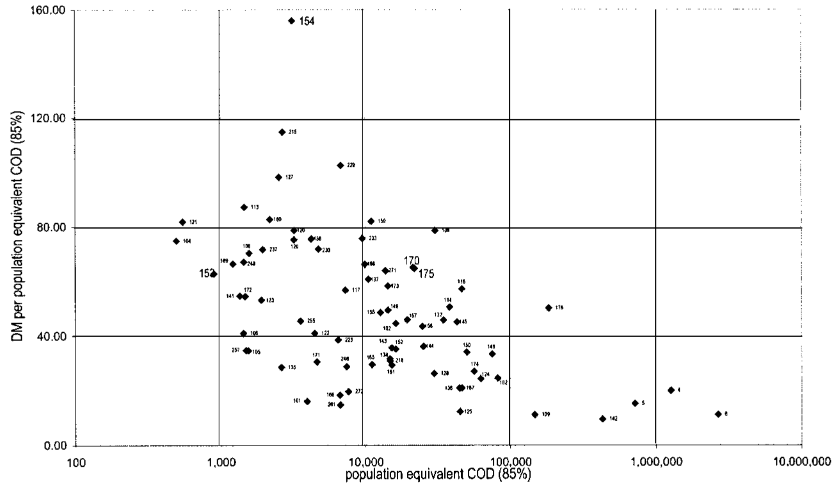

Figure 5 Standardised annual investment costs per population equivalent COD (85%)

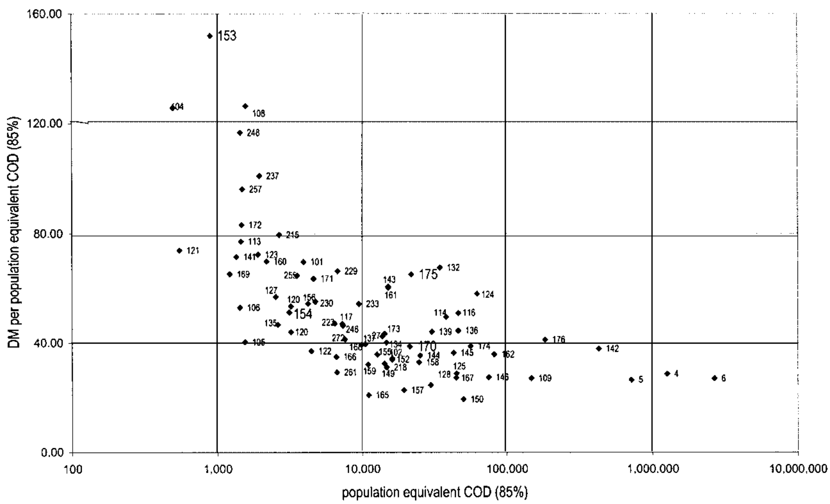

Figure 6 Standardised annual operating costs per population equivalent COD (85%)

competition sponsored by the German Federal Ministry of Education and Research on the subject of "Cost and Fee Reduction" in 1998. Our research proposal entitled "Benchmarking in Wastewater Disposal on the Basis of Technical-Economic Parameter-Systems", which we submitted jointly with the Aggerverband, the Universität der Bundeswehr in Munich and RTG Unternehmensberatung GmbH, has been selected by the jury as a nation-wide model project.

Although the project is still in progress, the following figures give an impression of the range of results. The performance indicator used in this overview is the real carbon load expressed as the 85% value of the COD, loads the costs of investment including using a unified method of standardised depreciation provision and interest; the operating costs were determined including the disposal of waste and the waste water tax and do also include the staff costs. The costs of energy, which are also included in the operating costs, do also include the costs for own generated energy (e.g. in the CHP).

On the basis of the Figures 4 to 6 first indications for the process comparison and the optimising potential can be found. The comparison between plant 153 and 154 shows the expected correlation between the investments and the operational costs. The addition of these two amounts leads to a similar result for both plants regarding the total costs per year. Looking at the plants 170 and 175 a similarity between the investments could be determined, but there are higher differences in operational costs. On one hand the differences can be put down to external circumstances, which cannot be influenced in many cases. On the other hand the differences partly indicate the optimising potential, which has to be worked out by a detailed analysis of the different treatment steps and specific costs.

Application

The approach described here has been applied to large WWTPs of the Emschergenossenschaft. The values derived were compared with those of a new partner (the city of Munich final presentation in November 1999). Here as well, it is quite clear that the approach selected produces good results with a reasonable level of cost and work input.

The offer we have extended to third parties to work with us in benchmarking was presented to a wide range of wastewater treatment plant operators in November 1998 and December 1999. A project involving nine participating plant operators (18 participating plants) from all over Germany will be finished in May 2000, another benchmarking project will be initiated this month with probably 10 participating operators and more than 20 plants. Furthermore in October 1999 we started an international comparison between three plants of Emschergenossenschaft/Lippeverband and three plants of private plant operators. We expect the results in 2000.

We also contacted English and Dutch wastewater treatment organisations for the purpose of developing an international benchmarking consortium. This will pave the way for a comparative study of the established benchmarks in co-operation with these other countries.

We are sure that benchmarking will soon become a standard management tool for our industry as well. It is an excellent method for mobilising elements of competition to promote development and to ensure long-term competitiveness.

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