

# International product cost comparison in the field of water management

H. Bode and P. Lemmel

Ruhrverband, Kronprinzenstraße 37, 45128 Essen, Germany

**Abstract** Comparing international costs in the field of water management is difficult. The frame conditions in the various countries are very different. They influence the costs and particularly the sewage charges in a complex way. Some of these conditions are outlined by analyzing the situation in Germany as a “case study”. An objective comparison should deal with the in situ arising product costs as annual costs. The product costs consist of both the operating and the capital costs. The annual product costs of 34 wastewater treatment plants in six different European countries are presented. The observed differences in the quality of the construction and of the mechanical equipment of the plants were taken into account with different depreciation periods. The product costs in four of six countries, including Germany, were found to be nearly at the same level. Although the German frame conditions are demanding and difficult the expectation of outstanding high product costs was not confirmed.

**Keywords** Cost; fees; drinking water; sewage; international comparison

## Introduction

The progressing globalization of the markets and the advancing growing together of the European countries – not least thanks to the advent of the European Monetary Union – have had their impact on the different sectors of water management in Europe. Contract-placing authorities and public bodies are bound to call for tenders on a European scale, as soon as the planned investments exceed specified thresholds. Building contractors and plant suppliers have recognized global markets for quite a while, the same as in the other branches of industry. Both the water suppliers and the builders and operators of wastewater treatment plants have a strong interest in finding out which position they hold in a cross-border comparison of services provided and costs charged. It is the objective of such a comparison to gain a better insight into the issue of costs and charges, and to weigh the results under consideration of all local particularities and frame conditions in the different countries under review. Such an approach does not only open up the chance for future cost reductions, but does also strengthen and promote water management and water conservation.

## The problems of supranational comparisons of costs and charges in water management

From time to time, the prices to be paid by the citizens for potable water and wastewater are represented in publications comparing the rates on an international scale. Yet when it comes to drawing meaningful conclusions from such comparisons, it soon turns out that they are only helpful if the national frame conditions are also being included in the considerations.

Charges and prices contained in such comparisons always stand at the end of a calculation that includes many factors being only determined to a minor degree by the actual costs for locally implemented measures. National taxation policy, for example, is such a factor influencing the calculation of water rates. Water management-related measures are state-subsidized in completely different ways via the overall tax revenue. And subsidized costs will roll back charges. Also “hidden” subsidies should be mentioned at this point as the

following example shows. In their recent study on international wastewater charges, Kraemer *et al.* (1998) state that tangible assets worth more than Euro 150 billion were sold for a sum around Euro 9.9 billion in the course of the privatization process of the British water industry (1 £ = 1.52 Euro). This transaction led to relatively low capital cost on the part of the operators – and hence to lower charges (which did not reflect the actual costs). According to the *Financial Times* (Owen, 1998), three of the ten leading British companies working in the water and wastewater sector made a profit before tax of 34% to 44% on their home-market turnover. This may be the result of the advantageous acquisition of the plants. Regardless of the final utilization of these profits (dividends, future infrastructure renewal etc.) this example shows that also the level of profit margins may affect the fees, which should not be left out of sight when assessing national prices.

Against the background of the steadily growing world population, making drinking water one of the most valuable resources in the world, the German weekly *Wirtschaftswoche* addressed the problem in 1998 indicating daily consumption figures and prices per cubic metre of potable water of the “big users” (see Figure 1). The data were released by the OECD and were also found in the *Economist*. It is hard to say, how reliable they are, since each evaluation might go back to different sources. The general tendency of the data is assumed to be alright.

The author(s) of the article explicitly complained about the high drinking water prices in Germany, but left out the simple multiplication of quantity and price. The result of which stands the cited facts on their heads, as is illustrated in Figure 2: since, for various reasons, people in Germany get along with relatively little water – without restriction on their comfort of living – they surprisingly spend much less money on drinking water than the citizens of the other countries. Only Italy comes off even better in this cost approach.

Experts know that the high investment costs in the water business – which to some extent do not depend on consumption figures anyway – react only very reluctantly to quantity changes in the consumption-related part. Hence, the low consumption figures in Germany having steadily declined over the last years inevitably lead to a relatively high price per cubic metre. In Germany, also the wastewater fees are generally charged according to the citizen’s fresh water withdrawal rate. The correlation between cost and quantity on the wastewater side is similar to that observed on the potable water side, whereby the quantity-related costs for a combined sewerage system, being designed for storm runoff, are even less affected by the specific consumption rates.

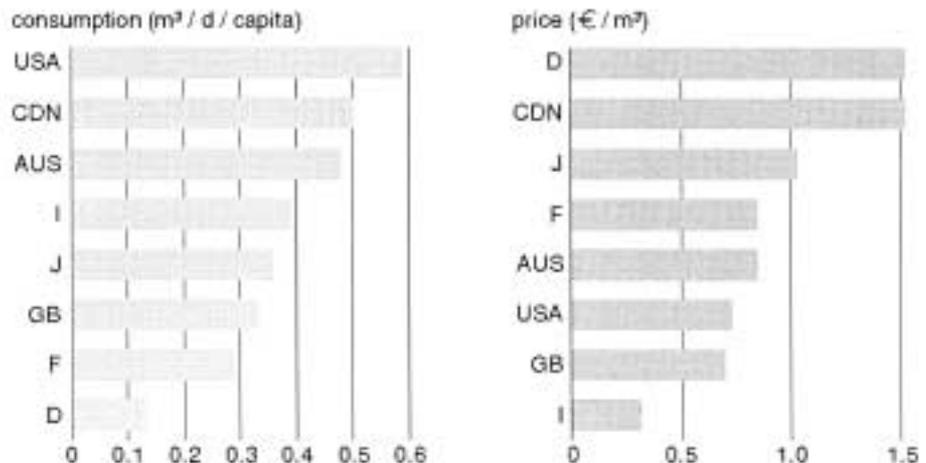
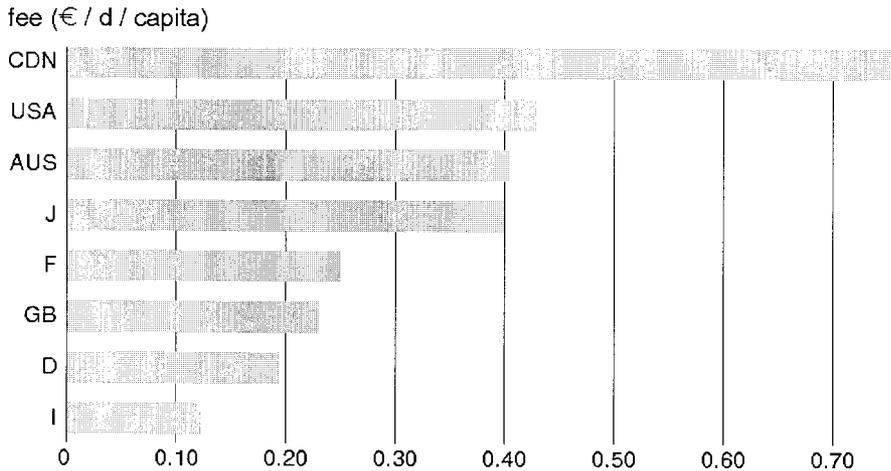


Figure 1 Average consumption and price of drinking water (*Wirtschaftswoche*, 1998)



**Figure 2** Average fee for daily consumption of drinking water per capita

It appears from the above examples that a simple comparison of figures relating to the specific national wastewater charges and drinking water prices is not a proper instrument to define the correct position on the global market which is the objective of this attempt. Doubtless it is more helpful to take the product costs actually arising in situ as the basis for a valid and reliable cost comparison. These product costs should only include two variables: the investment-related cost of capital and the cost of operation. Any cost elements not product-related must definitely be ignored.

However, such a comparison of costs does not yet consider or weigh the specific service output for the money paid and the significantly varying climatic, geographic, economic and social frame conditions. As regards Germany, for instance, any evaluation of costs at the national level should take into account that despite the given dense population

- the water running off the tap abundantly around-the-clock is fit for drinking throughout the country, and that
- the quality of the waterbodies has been remarkably enhanced over the last 20 years, which has positively contributed to the quality of life.

In comparison to this in some European countries, the quality of drinking water and of the surface waters is less favorable though major frame conditions – population density and industrial production – do not constitute an equally heavy burden on the resources of surface waters (the burden Germany has to cope with becomes evident when comparing the population density which is 229 inhabitants/km<sup>2</sup> in Germany with e.g. France where it is only 107 inhabitants/km<sup>2</sup>, accompanied by a by 25% smaller export volume per capita (Anon., 1997).

To illustrate cost-impacting frame conditions, it is worth considering the following items, as inter alia:

- The degree of supply and disposal safety (in Great Britain, for instance, some rather significant water supply bottlenecks were observed in 1996 (Schmitt, 1996));
- The degree of required disinfection measures in potable water; in some countries or regions, relatively large quantities of chlorine must be added to make the potable water hygienically safe. While high chlorine concentrations and their hazardous impact on health are still being discussed controversially, their presence remains a nuisance when the tap is opened. The typical pungent odor of chlorine does not invite the consumer to drink or use the water.

- Waterbodies (even large ones) are still heavily polluted in many countries, and the efforts undertaken to tackle the problem by enlarging sewage treatment capacity are rather inefficient at some places (Bode, 1998).

Whenever costs are compared, the performance must be considered, too. Due to this, the International Water Services Association (IWSA) established in 1997 a task force with the objective of preparing a system of Performance Indicators (PI) for water supply services which is suitable as an independent management tool. After foundation of the International Water Association (IWA) as a merger of IWSA and the International Water Quality Association (IAWQ) the IWA continues to develop the PI system. The PI system contains a large number of indicators regarding the special frame conditions as for example quality of service or operational indicators like i.e. total water losses ( $\text{m}^3/\text{connection}/\text{year}$ ). Last but not least also financial indicators are considered like unit running costs ( $\text{US}\$/\text{m}^3$ ) (Hirner *et al.*, 1998).

### Product costs of wastewater treatment in a cross-border comparison

In the face of the above outlined problems of a mere comparison of fees, a working group was set up by the German professional body BWK (Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau e. V.: association of engineers in water management, waste management and agricultural engineering) in 1997. Its task was to get a better idea of the actual costs involved by both construction and operation of wastewater treatment plants, and to get to know and to differentiate between as many relevant frame conditions as possible of the countries under review: Italy, France, Denmark, the Netherlands, and Switzerland. The study was sponsored by the Ministry of the Environment, Regional Development, and Agriculture of the State of North-Rhine Westphalia.

At first, some comprehensive investigations were initiated to determine the specific national frame conditions by literature studies, correspondence with local engineering offices, and discussions at home and abroad. A major result of this effort is a detailed table with more than 50 parameters which reflects the diversity of business environments in the different countries. It becomes evident how much not only the specific frame conditions, but also the planning and building procedures differ in the countries concerned. It also appears that some cost determinants mutually neutralize their impact. The solutions realized at the national level are often especially tailored to respond to regional and national conditions.

Simultaneously, a parallel investigation was made into the construction and operation costs of 5 to 6 wastewater treatment plants, per country, with similar treatment performances. The results of this investigation are summarized in Figure 3 as annual cost per inhabitant. Since investment costs are not a function of the number of inhabitants connected, but rather of the plant capacity, the total number of inhabitants and population equivalents (PT) was chosen as reference value to determine the specific investment costs. In case of not fully utilized plants, those operational cost fractions depending on the utilization rate were scaled up to full-load conditions. The actually paid investment costs served as the basis for calculating the cost of capital, which was recomputed into annual expenses using a uniform interest rate, and considering the partially varying depreciation periods. The study group detected distinct quality differences when they visited plants in the different countries. These concerned both the structures properly speaking (e.g. concrete covering, portion of steel reinforcement in the concrete, etc.), and the solidity and robustness of the mechanical equipment. The poorer quality found in some plants will lead, in practice, to a reduction of service life on the technical side, and hence to shorter depreciation periods on the commercial side. Except for Switzerland and Germany, overall writing-down periods had to be cut

by up to 25% for the building structures, and by up to 21% for the mechanical equipment. Whereas a uniform service life of 15 years could be assumed for the electro-technical equipment through all countries, because no quality differences worth mentioning were found. Figure 3 gives the results as arithmetical average for the number of plants investigated per country. Switzerland, Germany, Denmark, and France rank on top of the list of annual costs with values ranging from Euro 57 to 47 per total number of inhabitants and population equivalents. The Netherlands show markedly lower costs with Euro 40/(PT · a). But it should be noted that the average size of the plants investigated was essentially larger than that of the other plants. However, this is well in line with the mean value obtained when all plants in the country are being considered. Further, it should be mentioned that the average operational costs calculated for Germany include the expenditure for the statutory wastewater levies. German operators of sewage treatment plants must pay such levies in proportion to the pollution loads they discharge (AbWAG, 1994, "Waste Charges Act").

The cost for the wastewater levy to be paid by wastewater treatment plants with a comparable purification performance comes to Euro 1.6 to 2.6/(PT · a) (Bohn, 1998). Currently the wastewater levy is controversially discussed in Germany. If the levy should be repealed, the annual costs incurred in Germany will also fall close to a rate of Euro 50/(PT · a).

The individual proportion of capital cost to operating cost in the different annual expenses is essentially a function of whether any of the 6 or 5 facilities investigated per country perform anaerobic sludge stabilization. If so, the operating cost will decline, while the capital cost rise.

In the face of the differences found in design and the local prices, it was decided to use a fictive sewage treatment plant of 50,000 PT for a parallel model calculation of investment costs. Local unit prices were taken as the basis to calculate typical civil engineering, construction and equipment components, which were called up from a panel of various consulting engineering firms in the countries involved. This model calculation was aimed at arriving at a more objective and meaningful comparison which would be independent of the design and construction of the specific sewage treatment process and the random selection of the plants listed in Figure 3. The engineering fees and the cost of electrical equipment, installations, landscaping, etc., were not included for reasons of simplification,

	number of plants with anaerobic sludge digestion	capital costs		operating costs		annual costs	
		€/ PT · a	percentage of the annual costs [%]	€/ PT · a	percentage of the annual costs [%]	€/ PT · a	percentage of the Swiss annual costs [%]
CH	4 of 6	33	58	24	42	57	
D	3 of 6	29	55	24	45	53	
DK	1 of 6	17	35	32	65	49	
F	0 of 5	12	26	35	74	47	
NL*	3 of 6	20	50	20	50	40	
I	2 of 5	11	34	21	66	32	
arithmetical average		20	43	26	57	46	

*\*) all data of large wastewater treatment plants*

*design capacities 800 – 300,000 PT, representative samples of the different countries  
PT stands for the sum of load from population and industry: PT (total number of inhabitants and population equivalents = P (population) + PE (population equivalents (from industry)) – (EN 1085) –*

**Figure 3** Costs of sewage treatment in 6 European countries – in relation to the design capacity (Anon., 1998)

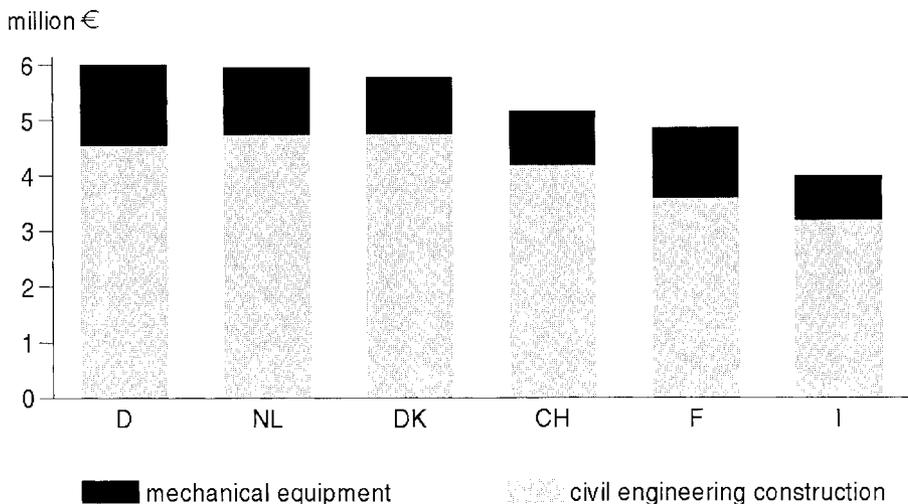
so that the indicated sum accounts for about 60% of the overall cost. The result of the model calculation is represented in Figure 4.

Investments in Germany and in the Netherlands were the same level. In Denmark, the costs were lower by 5%, in Switzerland by 15%, in France by 20%, and in Italy by even 35% lower. Surprisingly, civil engineering and construction in the Netherlands was more expensive than in Germany – by some 5%. On the other hand, the highest prices for mechanical engineering were paid in Germany. In conclusion, it can be stated that, except for Italy, the investment figures for the fictive plant are not so much apart, if – as was done – the civil and construction engineering is brought to a uniform quality level (steel and concrete quantities). As regards the mechanical engineering, it appears to be rather difficult to compare quality levels, as the country-specific unit prices may well refer to different quality standards.

The findings from both cross-border investigations (Figure 3 and Figure 4) show that of all countries considered, Italy definitely displays the lowest costs, while the figures of the other countries come relatively close. In the following, the results are discussed in greater detail. It is outlined why Germany, for example, is in the upper cost region, yet without dramatically exceeding the figures of the other countries in the group.

#### Description of various frame conditions affecting the cost of sewage treatment taking Germany as an example

In Germany, non-compliance with effluent permits of sewage treatment plants entails severe consequences under criminal law (StGB, 1994; Adams and Schendel, 1995). So everybody wants to be “on the safe side” in case of doubt when new treatment facilities are being planned: the responsible expert and the builder-owner alike. This scenario causes some additional costs. It is often the licensing authorities themselves urging the builders to dimension the facilities more “generously”. On occasion of the BWK-working group’s visits abroad, it was found that there is hardly any other European country in which so much courage is needed to size sewage plants in a more restrictive way. Even in countries where pollution of waterbodies falls also under criminal law, the individual decision-maker feels less “threatened”, as the social consensus around the implementation of legal standards is less stringent. Denmark may be cited as a good example in this connection. In Italy, the protection of waters has recently been made less stringent, and waterbody pollution removed from the penalty catalogue (Legge Merli/Merlinetta, 1995).



**Figure 4** Investment costs of a fictive sewage treatment plant for 50,000 PT (Anon., 1998)

Germany has declared itself a “sensitive area” to a very large extent, which involves application of more stringent discharge regulations. Moreover, the authorities release even higher demands in case of smaller receiving waters, which so far have not been integrated within the scope of European regulations. France, in contrast, has only declared about 30% of its catchment areas to be sensitive. The German measures take into account that Germany has no strong receiving coastal waters and that the country is densely populated and highly industrialized. The effluent standards therefore are more stringent than in most other countries.

Many wastewater treatment plants newly built or extended in Germany at the end of the 1980s, had to be retrofitted a short time upon their completion, because legal provisions on the discharge conditions were continually amended. A string of measures, partly overlapping, were required to adapt to the new statutory regulations and are currently still being written off.

German licensing authorities have a strong influence on the design and construction of wastewater treatment processes. In other countries, as for example in Denmark, only the discharge values to be met are specified. So it is the responsibility of the builder and operator to decide which technology – if possible a less expensive one – he wants to implement, and at what risk he is willing to do so. Further, this strategy allows the builder to use different bidding techniques (e.g. functional bid invitation) which might also contribute to cost savings.

In Germany, construction and reconstruction of sewage treatment plants involves a significantly greater expenditure for investment in the auxiliary areas compared to its neighbours (e.g., two completely separate areas for clean clothes and working clothes in the change and washing houses).

Generous and large-scale compensation measures are required by German law for any interference with the environment. Such measures, in particular if carried out in or at the waterbodies, are often very costly. To give an example: replacement areas must be acquired and reforested. For a new sewage treatment plant (of 90,000 PT) some 70,000 m<sup>2</sup> of land have to be recultivated which costs around Euro 310,000. In addition, some further Euro 205,000 have to be earmarked for greening the overall site of about 10 ha which must perfectly fit in with the surrounding landscape.

In many countries it is generally accepted that the treatment basins are simply set up on the terrain, thus remaining either fully or at least partly visible. This is doubtless a cost-saving solution. The available excavated earth is often used for filling up the ground around the treatment facilities, and the slopes are sowed down to grass, so that a certain “vision screen” is achieved. It can be stated that the cost advantages arising from less comprehensive excavation and construction work, otherwise required to counteract buoyancy and lateral soil pressure, mostly outweigh the additional cost for pumping the wastewater into the basins. In Germany, where relatively high demands on architectural structure and building construction are to be met, the above described type of construction is often still not being accepted (by the public). On the other hand, examples for challenging and expensive architectural solutions can also be found outside Germany.

The operating costs comprise personnel and energy expenses either directly or indirectly. Both components are above average in Germany, compared at the international level, impairing the overall product costs. The high German labor costs have since long been on the agenda of political and economic discussions in the country. Also the energy costs are still comparatively high, though a downward trend in prices has been observed since the liberalization of the power supply market in 1998.

On account of the rigid German statutory requirements with regard to the way in which residues have to be disposed of, comparatively high costs arise from the disposal of sewage sludge, grit and screenings.

German efforts to promote intermediate storage of combined wastewater and to treat it in the sewage plant after the rainfall have been steadily advancing compared with most other European countries. And the costs for implementing the necessary measures have significantly contributed to raising the wastewater fees (Bode and Willems, 1995).

The portion of the wastewater levy contained in the wastewater charges (for discharge and purification) is not so important – if considered in the absolute; yet any factor is relevant in a cost comparison. Not always the monies coming in as wastewater levy are transferred to the parties responsible for sewage disposal immediately and fully – as might be expected. Since the German wastewater levy is linked to the permitted effluent values, it becomes apparent that the sums to be paid are not a function of the actually discharged loads, but rather of those loads allowed by law (which is a parameter hardly fully “exploited” in practice).

Compared to other European countries, the scope of analytical and sampling techniques required by the German authorities with regard to self-monitoring in sewage plants and sewerage systems is quite demanding.

Engineering fees are linked to the amount of construction costs. And as such a relationship does not contribute to minimizing investments, some European countries have decided to abolish it.

## Conclusions

The present attempt made to determine the individual standing on an international scale – under consideration of the specific German conditions – leads to the following conclusions.

- The German citizen is obviously much less burdened with drinking water costs than stated, for example, in the paper published by Briscoe (1995). By the OECD-figures given in Figure 2, it can be assumed that – thanks to their low specific water consumption – the Germans fall within the category of countries with a rather low per capita cost burden.
- For wastewater, reliable cost and fee comparisons are not so easily established (see also: Barraque (1998)). And the results obtained will only be meaningful if sewage treatment performances are comparable (which they are not in most cases!).
- Similar annual costs were found with comparable wastewater treatment plants in France, Denmark, Germany and Switzerland based on a study in the scope of which 5 to 6 facilities were investigated per country; in the Netherlands, average plants were found to be larger, and hence more economical. The Italian plants investigated displayed the lowest annual costs (Figure 3). It is to be assumed that construction costs in Italy are generally at a very low level.
- When it comes to calculating the charges for wastewater treatment, it appears that there are a number of “adjusting screws” to play with. The original costs being the basis for computation essentially depend on whether or not the old plants had already been written off completely when the new construction or extension measures were launched. This is not always the case in Germany, on account of frequently changing regulations.
- Looking at Germany, it becomes evident that the German public holds a different view of many issues playing a part in water management in contrast to some of its neighbors. Such attitudes are the result of socio-political processes which are beyond the influence of technicians and engineers.

To sum it up: the results suggest that both the technical and economic efficiency of German drinking water supply and wastewater disposal utilities is rather high. The annual per capita cost for potable water is still at a fairly modest level – despite its excellent quality and ample availability (Figure 2). The wastewater costs still are on a par with those of the other countries under review – despite more difficult frame conditions (e.g. no strong receiving coastal waters (as, e.g., Great Britain) and a denser population and industry than

in most other countries.) It is a great success that by far most German surface waters are in very good shape and have fully recovered from the pollution observed in the 1970s.

## References

- AbWAG (1994). Gesetz über Abgaben für das Einleiten von Abwasser in Gewässer – Abwasserabgabengesetz, “waste charges act”. (BGBl. I p. 3370; 1996 p. 1690; 1997 p. 582; 1998 p. 2455).
- Adams, H. and Schendel, F.A. (1995). “Gerichtsfeste” Kläranlagen. *Korrespondenz Abwasser*, **11**, p. 2050 ff.
- Anon. (1997). *Der Fischer Weltatmanach* 98. Fischer Taschenbuch Verlag, p. 165 and p. 278–279.
- Anon. (1998). BWK-Working Group 2.4 “Kosten von Abwasserreinigungsanlagen im internationalen Vergleich”. Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau e. V., Düsseldorf.
- Barraque (1998). Europäische Antwort auf John Briscoes Bewertung der deutschen Wasserwirtschaft. *gwf Wasser • Abwasser*, **6**, p. 360–366.
- Bode, H. and Willems, G. (1995). Die Dimensionierung des Maximalen Mischwasserzuflusses zur Kläranlage vor dem Hintergrund der Kosten für die Niederschlagswasserbehandlung. *Schriftenreihe Siedlungswasserwirtschaft Bochum*, **31**, p. 129–147.
- Bode, H. (1998). Anmerkungen zu den Kosten der Abwasserreinigung in Deutschland. *Korrespondenz Abwasser*, **10**, Jahrgang 45.
- Bohn, Th. (1998). Einflussfaktoren der Betriebskosten bei der weitergehenden Abwasserreinigung – eine aktuelle Übersicht -. *Schriftenreihe WAR*, **108**, p. 11–27.
- Briscoe, J. (1995). Der Sektor Wasser und Abwasser in Deutschland. *gwf Wasser • Abwasser*, **8**, p. 422–432.
- Economist* (1998). Water, water, everywhere. *The Economist*, February 21st 1998, p. 53.
- Hirner, W., Alegre, H. and Baptista, J.M. (1998). Kostensteuerung und Qualitätssicherung bei Betrieb und Instandhaltung in der Wasserversorgung – Vorschlag für ein Kennzahlensystem. *gwf Wasser special* **139**; 13; p. 94–105.
- Kraemer, R.A., Hansen, W. and Pietrowski, R. (1998). Studie zu den Abwassergebühren im internationalen Vergleich. *Schriftenreihe Siedlungswasserwirtschaft Bochum*, **34**, p. 183 ff.
- Legge Merli/Merlinetta (1995). *Italian Law of Water Pollution Control and Waste Water Treatment (Italienisches Gesetz zum Schutz der Gewässer und Regelung der Abwasserreinigung)*. Legge Merli No. 319 dated 10.05.1997; Modification No. 113 dated 17.05.1995 (Merlinetta).
- Owen, D. (1998). European Water Company Profiles. *Financial Times Energy*, London.
- Schmitt (1996). Briten planen für den Wassernotstand. Duschen verboten. *Handelsblatt* dated 3/4 May 1996.
- StGB (1994). Strafgesetzbuch § 324, Bulletin dated 10.03.1987 (BGBl.I, p. 945, 1160) modified through Law dated 27.06.1994 (BGBl.I, p.1440) – BGBl.III 450–2 – Extract.
- Wirtschaftswoche (1998). Das blaue Gold. 35, p. 45, 1998; original reference OECD.

