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Water – More than a National Issue

Water is more than a national issue. The challenges in the water sector may be different – there are water-rich and water-poor regions, those that are more densely populated and others that are uninhabited, eminently industrial regions and others that are shaped by agriculture or just deserted. But the central challenge is always to provide a reliable water supply and sanitation and to eliminate residual materials and waste safely. Countries and continents of the earth are interconnected via the global water cycle, to a greater or lesser extent. Nevertheless, on a small scale, the idea could arise that one is self-contained, autarkic from the rest of the world.

Beside water quality, an important task of water management is to ensure that not too much water is in the same place, thus no flooding occur. Unfortunately, there are floods again and again, sometimes in countries where you may be not aware of major rivers, e.g. in the United Kingdom. For poorer countries the situation is even worse. On the other hand, droughts can also be disastrous – not only in Africa or Asia, but also in Europe or the USA, e.g. in California, which currently (2016) faces its fifth year of severe drought.

The water industry is constantly facing new challenges. The demographic development in some industrialized countries has implications for the water industry and its infrastructure – the costs including a high proportion of fixed costs have to be shouldered by a decreasing population. Anthropogenic micropollutants in the water cycle require increasing attention of water experts: With an ageing population more active pharmaceutical substances can be expected in the wastewater. Climate change affects the water cycle – storm rainfalls increase in intensity and frequency and their seasonal distribution varies.

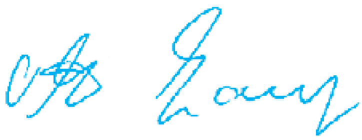
If the world population continues to grow as projected, the environmental issue is likely to increase in importance, especially in countries where the protection of the environment does not yet carry great weight. Water in this respect is assigned a particular role, it is the basis of all life as we know it on Earth. Population growth also means more waste that must be disposed of so that people are not harmed. Waste as well as wastewater should be regarded more as a source of raw materials. In this context, the slogan "Urban Mining" has become a well-established term. But more people mean more living space, more residential areas, major cities, more infrastructure, including sewage treatment plants and various other water management facilities.

For many questions that arise in dealing with water, technical solutions already exist. Especially in Germany, environmental technology and water management are well developed. Technical standards are developed by professional bodies like the German Association for Water Management, Wastewater and Waste (DWA) or the German Technical and Scientific Association for Gas and Water (DVGW). In these organizations, the professionals and thus the expertise is organized. For many years, the DWA, who is the publisher of this journal, has been working in international standardization bodies. Standardization on an international level is useful for operators as well as suppliers of technical equipment. The DWA is counseling internationally in the sector of vocational training, good professional practice (Technical or Sustainable Safety Management), but also cares about the international junior professionals.

In Germany there are flagship events of global importance in the areas of water and environment (IFAT, Wasser Berlin), chemical engineering/process industry (ACHEMA), information technology (CeBit), technology in general (Hanover Fair) and many other large and small special events more which are related to water. Of these, the most important for the water sector is IFAT in Munich. IFAT has been founded in 1966, thus celebrates its 50th birthday in 2016 with its 19th edition. Credit for the first IFAT is in a large part due to the above-mentioned DWA which had organized an international conference with a trade show in 1966 for the International Association on Water Pollution Research (IAWPR), now the International Water Association (IWA). IAWPR moved on, IFAT was born and stayed in Munich with DWA as its principal conceptual sponsor ever since.

A small section of the German water sector and the international activity of the DWA is highlighted in this journal. There are articles on sewer systems and storm water treatment in Germany, the performance of municipal wastewater treatment plants in Germany and more.

I hope you enjoy reading one or the other article which the editor of this "special issue in English" of DWA's member's journal has chosen to publish. Thank you for your time.



Bauass. Dipl.-Ing. Otto Schaaf
President of the German Association for Water Management, Wastewater and Waste (DWA)

		Publication	Euro
☐ Guideline DWA-M 366E	New	**Mechanical Dewatering of Sewage Sludge** February 2013, 51 pages, A4, ISBN Print: 978-3-944328-28-7, ISBN E-Book: 978-3-88721-347-3 Dewatering of sewage sludge is one of the most important fundamental process steps in the entire sludge treatment chain. This Guideline summarises commonly used systems as well as their dewatering efficiency and cost effectiveness and presents information on operational requirements and conditions. It also supplies information on the optimisation of dewatering results and on the minimisation of electrical power consumption. Especially, planners and operators of wastewater treatment plants are addressed by this Guideline.	62,00 *
☐ Guideline DWA-M 512-1E	New	**Sealing Systems in Hydraulic Engineering – Part 1: Earthwork Structures** February 2012, 112 pages, A4, ISBN Print: 978-3-944328-46-1, ISBN E-Book: 978-3-88721-346-6 This Guideline deals exclusively with sealing systems designed for application in hydraulic engineering. Described are surface and internal sealing systems used in earthwork structures, including asphalt and concrete sealing systems, geosynthetic clay liners, mineral sealings, geomembranes, fully grouted riprap, sheet pile walls and internal sealing systems made of hydraulically bound sealing-wall materials. For each of these sealing systems, a summary is given of possible applications, construction materials, methods of placement, design principles, quality assurance and maintenance requirements.	85,00 *
☐ Guideline DWA-M 514E	New	**Dam Surveillance** July 2011, 77 pages, A4, ISBN Print: 978-3-942964-54-8, ISBN E-Book: 978-3-88721-329-9 Consistent monitoring plays an essential role in dam safety management. Individually adjusted measuring and monitoring systems are employed for the purpose. Being applied in combination with periodical visual inspections, these measuring efforts provide plant operators with a comprehensive and differ rentiated picture of the structural and operational safety status of their dams. This Guideline provides supplementary information and also serves as a basis for the planning, approval, design, implementation and validation of dam surveillance concepts established for both new and old dams.	66,00 *
☐ CD-ROM	New	**DWA Set of Rules – English Version on CD-ROM** Edition April 2016 – English translations of significant publications of the DWA Set of Rules, 52 DWA-Standards and Guidelines, 6 DWA-Topics and various brochures in pdf format (single user)	298,00 *
☐ Technical Book	New	**Fit in Wastewater Technology?** 2014, 111 pages, A4, ISBN Print: 978-3-88721-247-6, ISBN E-Book: 978-3-88721-330-5 Also available as Flashcard app, see www.brainyoo.com This new concept was specifically developed for the practical and comprehensible transfer of knowledge for the occupation of „wastewater engineering technician". The book contains conventional multiple-choice questions plus questions related to situations for the better understanding of processes, expedition questions to apply the theory to the practical work on a wastewater treatment plant and questions for reflection which should be discussed and solved with a trainer.	29,50

		Publication	Euro
☐ Flyer	New	**Caution, a pump killer!** **The wet wipe problem** 2015, 4-colored, DINlang Wet wipes clog pipes and canals. Restoring the water flow costs money and is labour intensive. It does not have to be this way. The flyer points to the problem of wet wipes and give tips for optimal handling of it. The prices are not transferred to your order confirmation when ordering via the DWA-Shop. Please order larger numbers by e-mail to info@dwa.de.	net price: per piece 0,25/pce from 100 piece 0,20/pce from 250 piece 0,15/pce from 500 piece 0,10/pce from 1000 piece on enquiry
☐ Flyer	New	**What can go in the toilette?** 2016, 4-colored, 12 pages, DINlang This flyer gives a compact and comprehensible description of what belongs in the toilet or in the waste bin and which wastes must be disposed of separately. The flyer is used especially as information for persons applying for asylum and includes the following languages: German – Amharic – Arabic – English – Farsi – French – Kurdish – Pashto – Russian – Somali – Tigrinya	net price: per piece 0,30/pce from 100 piece 0,25/pce from 250 piece 0,20/pce from 500 piece 0,15/pce from 1000 piece on enquiry
☐ Poster	New	**Correct waste disposal – Toilet or waste container?** A3 This poster illustrates in easily understandable drawings what belongs in the waste container and must not be disposed of in the toilet. The poster was designed as basic information about correct waste disposal especially for persons applying for asylum.	2,50

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Under the Focus of Statistics: Sewerage and Stormwater Treatment in Germany*)

Hansjörg Brombach (Bad Mergentheim/Germany) and Joachim Dettmar (Saarbrücken/Germany)

Summary

Diagrams based on the latest data made available by the German Federal Statistical Office for the report year 2013 show the status of public sewage systems in Germany, the number of stormwater tanks in the sewerage system, and the number of public wastewater treatment plants. For all federal states, figures are given for the amount of drinking water delivered, the proportion of inhabitants connected to the public sewerage, the lengths of sewer per inhabitant, the geographical distribution of combined and separate sewer, the number of stormwater tanks with the annual average infiltration/inflow rate there, along with the growth in the number of stormwater facilities since 1975.

Key words: drainage systems, sewerage, urban drainage, water delivery, connection rate, sewer, length, stormwater tank, combined system, separate system, wastewater treatment, infiltration water, statistics, federal state, Germany

1 Introduction

There are seven precursors [1–7] to this paper that have appeared with similar title and contents in this periodical. In connection with the series of reports, whose history now goes back for 37 years, the status and development of sewage systems and stormwater tanks in Germany is presented through statistics and diagrams on the basis of the latest official data produced by the Federal Statistical Office (DESTATIS) for report year 2013. The similarity to these publications has been deliberately preserved to simplify a comparison with previous articles.

2 The latest DESTATIS database from 2013

The German Federal Statistical Office (DESTATIS) collects data on water supply and wastewater disposal in Germany in a three-year cycle. The last-but-one census was taken in 2010. The latest data from census year 2013 has now been available in full since December 2015 [8–10].

The figures given in the quoted sources relate exclusively to the public water supply system and to the public wastewater disposal systems belonging to local authorities, functional associations and other institutions and corporations under public law.

According to Section 56 of the Water Resources Act [11], the wastewater produced must be dealt with by legal persons under public law, which are specified by the states. Municipalities and water associations with special legal status usually perform the task of wastewater disposal, depending on the particular federal state. The relevant state and federal road authorities are responsible for the drainage of federal and state roads and motorways outside the municipalities and association areas. It is assumed that this is one reason for the absence of data relating to a large number of stormwater tanks that have been installed in recent years, particularly in the stormwater sewage system of the motorway drainage systems.

Independently of and in parallel with this, DESTATIS records the data for “Non-public Water Supply and Non-public Wastewater Disposal” [12]. This covers private and commercial water consumers. 92 % of this water flow consists of the cooling water from power stations. The non-public use of water is not considered in this article.

All the primary data in Table 1 that contains a reference to the literature in the third line, “Source”, has been taken over unchanged from the DESTATIS publications [8–10]. The secondary data in the columns where no sources are quoted [–] have been derived from the DESTATIS database by the authors. As a result of rounding the figures for various states up and

*) The origin of this paper got published in German, this is a revised English version. Brombach, H., Dettmar, J.: Im Spiegel der Statistik: Abwasserkanalisation und Regenwasserbehandlung in Deutschland, *Korrespondenz Abwasser* 2016 (3), 176–186

Statistical magnitude Csys: combined system Ssys: separate system	Inhabitants on 30.06.2013	Water delivery for final consumption to households and small businesses	Proportion of inhabitants connected to the public sewerage, Csys+Ssys	Length of combined sewers, CS, Csys	Length of sanitary sewers, SS, Ssys	Length of storm sewers, StoS, Ssys	Total length of sewers, Csys+Ssys	Length of sewer per inhabitant, Csys+Ssys	Proportion of the population connected to combined sewer systems	Combined sewer overflow tanks (CSO-Tanks) and combined inline tanks with overflow (IT), number, Csys	Combined sewer overflow tanks (CSO-Tanks) and combined inline tanks with overflow (IT), volume, Csys	Stormwater retention tanks (RTT), number, Csys+Ssys	Stormwater retention tanks (RTT), volume, Csys+Ssys	Stormwater clarifier tanks (CT), number, Ssys+Ssys	Stormwater clarifier tanks (CT), volume, Ssys+Ssys	Total of all stormwater tanks without CSO, number, Csys+Ssys	Total of the volumes of all stormwater tanks, Csys+Ssys	Storage volume per inhabitant, Csys+Ssys	Combined sewer overflows (CSO) without calculable storage volume, number, Csys	Total of all stormwater tanks, number, Csys+Ssys	Public wastewater treatment plants (WWTP), number, Csys+Ssys	Mean I/I-rate wastewater treatment plants intake, Csys+Ssys
Column 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Source in the literature	[8, 10]	[8]	[10]	[10]	[10]	[10]	[10]	[-]	[-]	[10]	[10]	[10]	[10]	[10]	[10]	[-]	[10]	[-]	[10]	[10]	[9, 10]	[9]
Dimension	1,000 P	l/P·d	%	km	km	km	km	m/P	%	n	1,000 m^3	n	1,000 m^3	n	1,000 m^3	n	1,000 m^3	m^3/P	n	n	n	%
Germany	**80,586**	**121.2**	**96.9**	**242,866**	**206,234**	**126,480**	**575,580**	**7.14**	**54.1**	**24,441**	**15,078**	**22,621**	**39,004**	**3,747**	**2,576**	**50,809**	**56,658**	**0.703**	**20,929**	**71,738**	**9,307**	**44.5**
Baden-Württemberg	10,598	116.4	99.4	50,155	12,550	11,199	73,904	6.97	80.0	7,098	3,922	780	1,566	354	175	8,232	5,664	0.534	3,816	12,048	972	93.2
Bavaria	12,549	129.5	97.1	55,248	30,479	13,924	99,652	7.94	64.4	6,491	3,198	4,180	4,146	707	560	11,378	7,904	0.630	4,025	15,403	2,480	36.2
Berlin	3,394	113.8	99.6	1,965	5,543	3,330	10,837	3.19	26.2	23	67	101	700	20	49	144	816	0.240	450	594	1	-
Brandenburg	2,447	107.8	87.7	616	15,383	4,528	20,527	8.39	3.9	58	66	514	775	266	68	838	909	0.371	304	1,142	243	3.9
Bremen	655	120.6	99.7	803	1,103	1,215	3,121	4.76	42.1	6	80	15	60	59	26	80	165	0.252	21	101	4	12.0
Hamburg	1,743	138.1	99.2	1,258	2,840	1,731	5,830	3.34	30.7	12	99	9	48	31	91	52	239	0.137	148	200	1	16.2
Hessen	6,025	124.3	99.5	29,261	4,399	5,361	39,021	6.48	86.9	2,777	1,814	1,047	1,179	42	49	3,866	3,043	0.505	3,089	6,955	696	106.8
Mecklenburg-Vorpommern	1,597	104.5	88.7	601	10,989	4,116	15,705	9.83	5.2	105	116	613	1,172	230	177	948	1,465	0.917	375	1,323	595	13.4
Lower Saxony	7,789	126.4	94.5	3,358	46,619	28,982	78,958	10.14	6.7	211	378	4,670	11,215	98	121	4,979	11,714	1.504	553	5,532	613	19.6
North Rhine-Westphalia	17,546	133.4	98.0	46,360	28,872	23,388	98,619	5.62	61.6	2,832	3,061	4,948	10,171	1,175	503	8,955	13,735	0.783	1,895	10,850	634	40.5
Rhineland Palatinate	3,989	118.6	99.4	21,998	6,199	4,809	33,006	8.27	78.0	2,586	1,113	1,755	2,268	60	40	4,401	3,421	0.858	2,592	6,993	680	51.5
Saarland	992	113.6	99.5	6,636	586	925	8,146	8.21	91.9	667	320	121	153	17	47	805	519	0.523	1,516	2,321	136	90.0
Saxony	4,042	86.3	91.6	9,960	11,473	5,669	27,102	6.71	46.5	667	365	939	1,545	138	130	1,744	2,040	0.505	1,155	2,899	677	57.1
Saxony-Anhalt	2,249	92.6	94.7	3,440	12,636	4,536	20,612	9.16	21.4	198	133	571	689	34	41	803	863	0.384	339	1,142	239	24.5
Schleswig-Holstein	2,808	129.8	94.8	1,614	12,925	10,140	24,680	8.79	11.1	60	68	1,679	2,635	461	460	2,200	3,164	1.127	124	2,324	790	10.9
Thuringia	2,164	88.3	93.5	9,596	3,638	2,628	15,862	7.33	72.5	650	278	679	681	55	39	1,384	998	0.461	527	1,911	546	43.2

Comment: [-] figures calculated from the sources; - no data available

Table 1: Statistical figures for public water supply, public wastewater disposal and rainwater treatment on the basis of the data collected by the German Federal Statistical office for the report year 2013

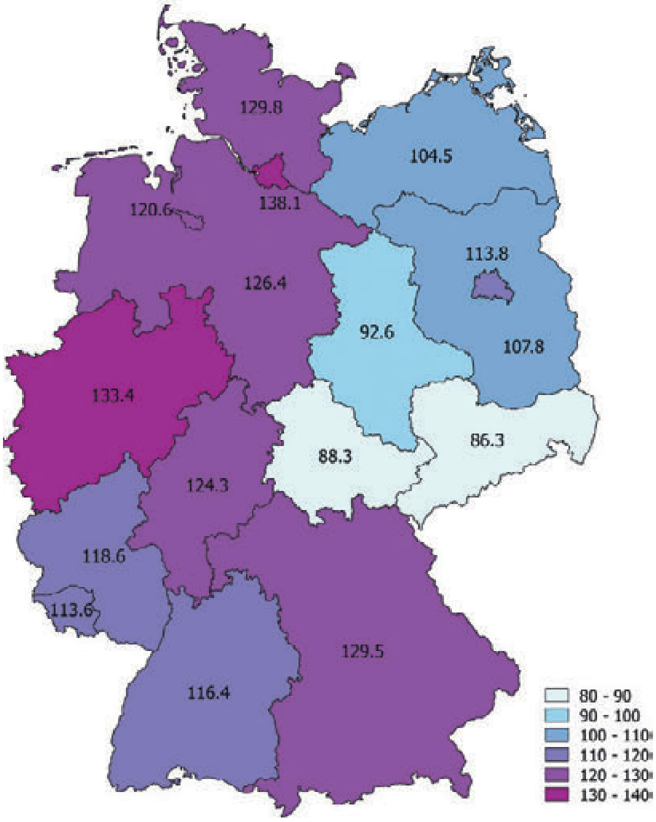

Fig. 1: Water delivery for final consumption to households and small businesses in litres per day and inhabitant for the report year 2013

down, there may be slight variations in the last figure of the totals of the "Germany" line.

None of the illustrations shown below referring to the federal states are contained in the reports from the Federal Statistical Office [8–10], and have been prepared on the basis of the figures in Table 1.

3 Population and water consumption

Three terms are used for the population data in the DESTATIS figures [8–10]: number of inhabitants (P), population equivalents (PE) and total number of inhabitants plus population equivalents (PT). In order to avoid confusion, only the number of inhabitants e.g. population will be used below.

The population (P) in column 2 of table 1, taken from sources [8, 10], refers to the population living in the respective federal state on 30 June 2013. It should be noted that the population has a shaky basis, since a population count has not been carried out since 1987, simply an extrapolation on the basis of a representative survey last performed in 2011. As a result of the present influx of immigrants, the figure for the actual population will in future become even less certain.

In relation to Germany's total area of 356,954 km², these 80.586 million inhabitants represent a population density of 226 inhabitants per square kilometre. Germany is a densely populated country with long flow paths to the North Sea, the Baltic and to the Black Sea, so that wastewater treatment will continue to remain an important topic for our country in the future.

The drinking water consumed in households and small businesses is the source of contamination and, at the same time, the transport medium in the combined and sanitary sewers. The first diagram (Figure 1) is therefore dedicated to drinking water consumption. 99.3 % of the population is nowadays connected to a public water supply, and consumes a long-term federal average of 121.2 litres of drinking water per person each day – see column 3 in Table 1. Of this, according to [9], a daily average of 118 litres per total number of inhabitants and population equivalent (PT) arrived at the wastewater treatment plants as domestic and commercial sanitary sewage in census year 2013.

The delivery of water varies sharply from one federal state to another. Saxony has the lowest specific water delivery at 86.3 l/(P · d), while in North Rhine Westphalia it is more than 50 % greater at 133.4 l/(P · d). There is, however, no need to worry about this, since Germany is a country with plenty of water and, on an international comparison, has a moderate water consumption. Very clear maps of Germany showing the water budget related to each administrative district for the report year 2010 can be found in [13].

4 Connection rate to public sewerages

The mean connection rate of inhabitants of the Federal Republic of Germany to the public sewerage in report year 2013 was 96.9 % according to [10]; see column 4 of Table 1. The mean connection rate has increased by 0.3 % since report year 2010. Even 25 years after reunification in 1990, the new federal states can still be distinguished by their slightly lighter colour

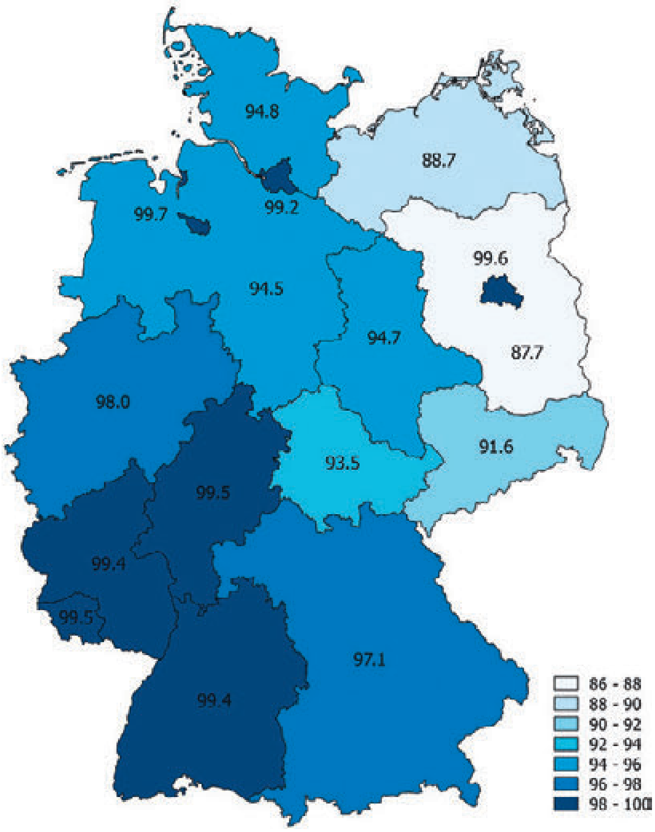

Fig. 2: Proportion of inhabitants connected to the public sewerage as percentage of the population, midyear, report year 2013

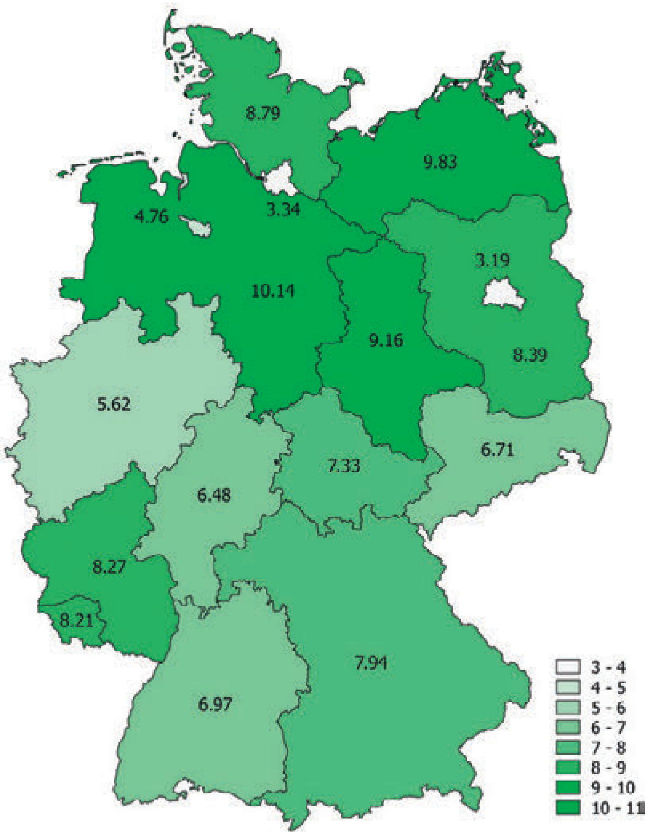

Fig. 3: Length of public sewers in metres per inhabitant; report year 2013

(Figure 2). This is, however, not unreasonable, and the differences will continue to balance out.

The seven federal states of Baden-Württemberg, Berlin, Bremen, Hamburg, Hessen, Rhineland Palatinate and Saarland have connection rates to the public sewerage of 99 % and more, and have therefore reached practically complete connection.

5 Length of the public sewers

The length of the public sewers from [10] (without private household connections, without commercial sewers and without either the sewers of the state and federal roads or motorways) is given in columns 5 to 8 of Table 1. In total there were 575,580 km of combined (CS), sanitary (SS) and storm sewers (StoS) in Germany by the end of 2013. Since 2010, therefore, the length of German drains has grown by 2.5 %, i.e. an annual growth of 0.8 %. Between 1998 and 2004, the growth was 2.6 % per year. The rate of growth has thus dropped to a third. That would appear plausible.

If the total length of all the public sewers in column 8 is divided by the number of inhabitants in column 2, we obtain the mean sewer length per inhabitant; see column 9. The federal average is 7.14 m of public sewer per inhabitant. Since 2010, an average of 27 cm of public sewer has been added for each federal citizen, which is 9 cm of sewer per year. Over the period from 1998 until 2004, the figure was 13 cm of additional sewer per inhabitant and per year. The falling rate of growth is also plausible in the light of the trend in the connection rate.

Figure 3 shows a comparison of the federal states in terms of the mean sewer length per inhabitant. It is easy to see that the city states manage with relatively “short” sewers. Berlin at 3.19 m, Hamburg at 3.34 m and Bremen with 4.76 m per inhabitant hold the record for the “shortest” sewers. This is the infrastructure advantage of a big city. Lower Saxony, with a very high proportion of rural areas, and a sewerage that is 93.3 % separate, has the greatest length of sewer per inhabitant in Germany at 10.14 m.

The new federal states have clearly mastered the need to catch up with the development of the sewerage. There are now no longer large differences from the old federal states.

6 Separate and combined sewer systems

There are no direct figures in [8–10] regarding the distribution of the population between separate (Ssys) and combined (Csys) sewer systems. It is alternatively possible, however, as was also done in the earlier contributions, to draw conclusions as to the proportion of the population connected in each case from the ratio of the lengths of the combined and sanitary sewers, as follows:

CS	combined sewers from column 5 in km
SS	sanitary sewers from column 6 in km
PCS	proportion of population connected to combined sewer systems from column 10 in %
PSS	proportion of the population connected to separate sewer systems (without column) in %

PCS = [CS/(CS + SS)] × 100
PSS = 100 – PCS

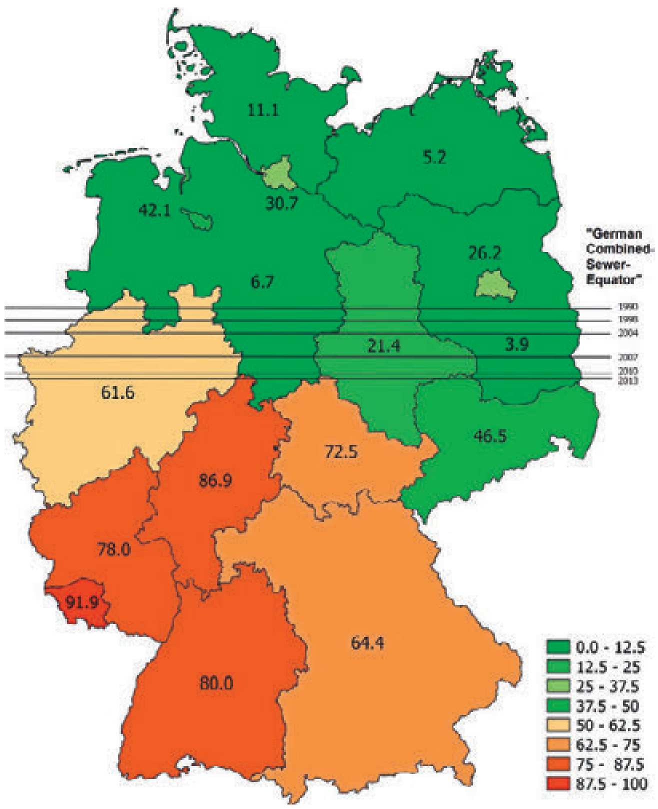

Fig. 4: Proportions of inhabitants connected to combined sewer systems in % at the end of 2013

It has been assumed here that on average a similar statistical distribution of the connection rate for the population per metre of sewerage system is present, independently of the drainage system (separate or combined sewer systems). In this calculation, the length of the storm sewers (StoS) is not relevant.

The above assumptions assign too high a proportion of the population to the separate system. Separate drainage dominates in rural areas, such as can be seen in Figure 4 for Brandenburg, Mecklenburg-Vorpommern and Lower Saxony, and in the newer suburbs and development areas of cities. The population density is lower there, and the sewers are longer per inhabitant. Even now, however, it is not known how many inhabitants are in fact connected to which drainage system. The PCS formula is retained in order to preserve the parallel with the earlier articles in this series.

A scale based on two colours is used in the illustration of Figure 4 in order to emphasise differences. All the federal states where the proportion of combined systems is less than 50 % (lowland) are coloured between dark green and light green. The federal states where the proportion of combined systems is more than 50 % (highland) have a yellow to red colour.

If we compare Figure 4 with the status since the first analysis [3], it is noticeable that, without exception, separate sewage systems have gained ground in every federal state. In 1989/90, the federal average was 71.2 % combined sewer systems. In the current report year 2013, the proportion of inhabitants connected to the combined sewer system still remains at 54.1 %.

If we draw a boundary at a 50 % proportion of combined as against separate systems through the middle of Germany, we find what is ironically called the “German combined water equator”. According to the estimate, as shown in Figure 4, this line has, on average, moved about 3.5 km further south per year since 1990. In fact, however, the equator now ought to tilt from the north-west to the south-east. To keep the equator still running from west to east, the part of Saxony south of the equator has been “reckoned in” with the northern part of North Rhine-Westphalia.

The north-south difference in drainage systems has long been present, but has now sharpened. The “combined water equator” now no longer lies on a ramp, but marks a cliff! South of Lower Saxony, Thüringen and Brandenburg, the proportion of combined systems jumps by a factor of 10. The city states of Bremen, Hamburg and Berlin tower, like “Helgoland pillars”, out of the flat surrounding lowlands.

7 Stormwater tanks

The DWA-A 166 [14] worksheet, which appeared in 2013, divides the central stormwater treatment and retention facilities in the combined system into stormwater tanks with overflow (CSO-tank), sewers with storage capacity and overflow (IT), retention soil filter basins (SRSF) and stormwater retention fa-

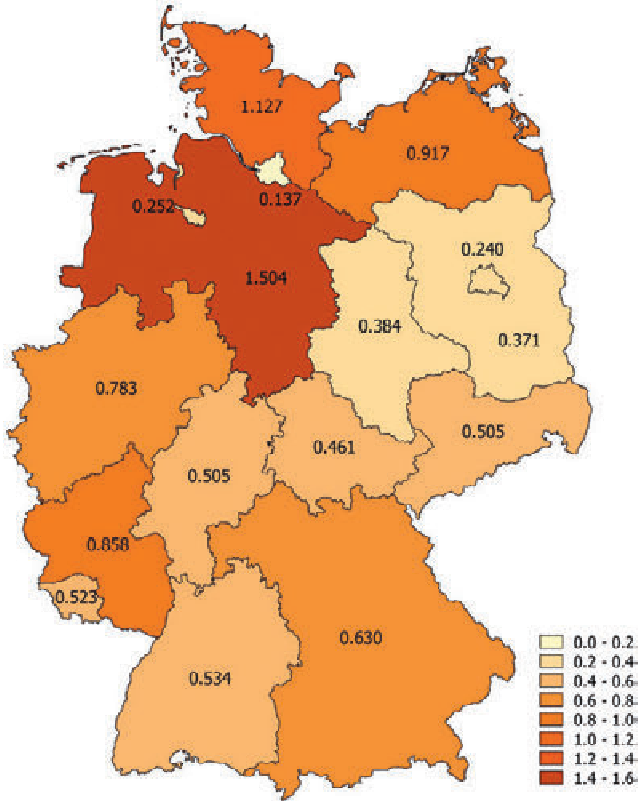

Fig. 5: Storage volume for rainwater in the public sewerage in cubic metres per inhabitant, report year 2013

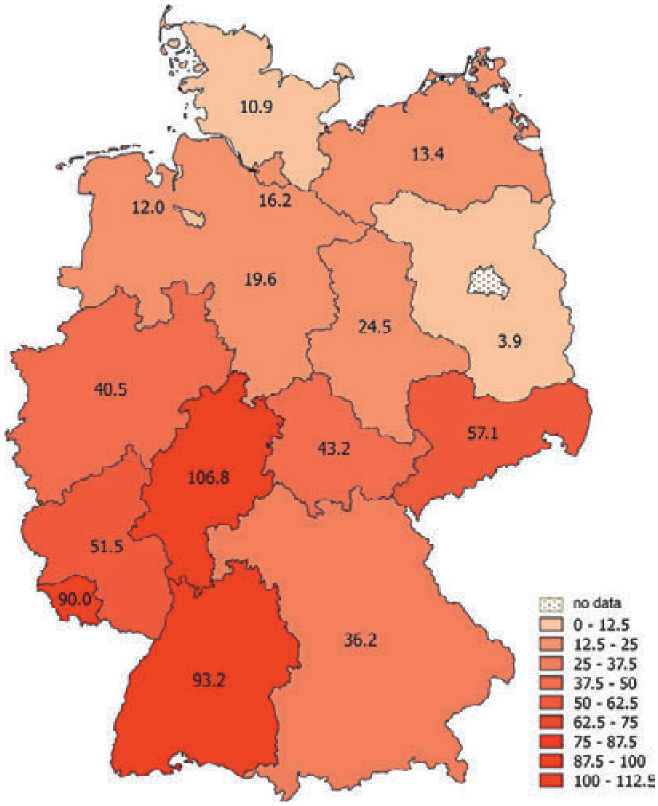

Fig. 6: Mean additional infiltration / inflow water as a percentage of the incoming sanitary sewage, report year 2013

cilities (SRSF), while in the separate system the distinction is between stormwater clarifier tanks (CT), retention soil filter basins (SRSF) and stormwater retention facilities (RTT).

The Federal Statistical Office has so far only partially adopted this classification. It does not explicitly list any sewers with storage capacity and overflow, although these are in fact included under the heading of stormwater tanks with overflow. It is not clear which of the stormwater retention facilities that are recorded are assigned to which drainage system. Retention soil filter facilities are not recorded at all, although this would be advisable in the light of their growing number. For the sake of easier assignment, the top line of Table 1 has been supplemented with "Csys" and "Ssys" for combined and separate systems respectively.

In columns 11 to 16, Table 1 shows the existing number of basins and their volumes. If we put the STO, SSCO, SRF and SST together, i.e. structures that hold significant volumes, under the general term "stormwater tanks", similarly to DWA-A 166, then by the end of report year 2013 the total for Germany is an impressive 50,809 (1998: 31,044; 2004: 41,569; 2007: 45,457; 2010: 47,678), with a total volume of 56.658 million cubic metres (1998: 33.143; 2004: 46.753; 2007: 52.259; 2010: 53.880); see columns 17 and 18.

If the retention volumes of stormwater tanks created over the last 40 years or more in the public sewerage – not including the volumes of the retention soil filter basins, which are not included in the count, without adding the "silent" retention volume of combined sewer overflows (CSO), and without the natural retention of the flowing wave – are divided arithmetically, evenly across the population, the numbers illustrated in column 19 of Table 1, with which Figure 5 was prepared, are obtained.

The systematic advantage of a megapolis can again be seen for the city states of Hamburg, Berlin and Bremen, which manage with the lowest specific retention volumes. The area states of Lower Saxony, Schleswig-Holstein and Mecklenburg-Vorpommern, with their large rural areas and predominantly separate sewage systems, have the highest specific retention volumes. It can be seen that there is a need for Brandenburg and Thüringen, where sewage is again predominantly separate, to catch up.

At the end of 2013, an average storage volume of 0.703 m^3/P (2004: 0.567; 2007: 0.635; 2010: 0.659) was available for the central retention and treatment of rainwater. This corresponds to a growth of 44 litres over three years, or 2.2 % per year.

If we assume a mean specific construction expense of 1000 EUR per cubic metre of storage volume, then the development of rainwater treatment has cost each federal citizen 703 EUR – even if it hasn't been noticed. At first sight this may look like a lot of money, but when divided over the last 40 years, the expense comes out at just about 20 EUR per inhabitant per year.

With the present generation rate of around 118 litres of sanitary sewage per inhabitant per day, then in theory the retention volume in the public sewerage now present would be enough to store domestic wastewater for almost six days – if there is no rain, and if there is no infiltration / inflow water.

8 Infiltration and inflow water (I / I)

According to the DWA-M 182 leaflet [15], I / I-water is the water flowing into drainage systems whose properties have not been changed either by domestic, commercial, agricultural or other usage, or by precipitation collected by built-up or paved areas and introduced as intended. The amount of I/I-water depends on the groundwater level and the weather, is different from year to year, and has great variation both seasonally within any one year and locally.

Since 1987, the Federal Statistical Office nevertheless polls, the annual flow of sanitary sewage, stormwater and I/I-water into all of Germany's wastewater treatment plants (WWTP) as total number of inhabitants and population equivalents of more than 50 connected. From practical and scientific points of view, however, it is in fact not at all easy to draw conclusions about the annual infiltration rate from the measured input to wastewater treatment plants. It is clear that the quantity of infiltration water is determined using different methods in various federal states (annual sanitary sewage method, night minimum method, methods with moving minimums) – or is simply estimated. The new DWA-M 182 leaflet on the topic of infiltration water [15], which came out in 2012, was also unable to supply a method for determining the annual infiltration rate that could be uniformly applied across the country. Something must be done to prepare infiltration water statistics that are consistent across the country.

The "infiltration/inflow rate" in Figure 6, not to be confused with the "infiltration proportion", is the annual average of the I/I-water, expressed as a percentage, entering the wastewater treatment plants in addition to the sanitary sewage.

Over the report year 2013, the federal average of the I/I-rate was 44.5 % (2004: 34.8 %; 2007: 40.3 %, 2010: 45.9 %). Figure 6 is highly inconsistent. The state of Berlin has not provided any figures for infiltration water for years, since five of its six wastewater treatment plants are located outside the city. In Hessen, the infiltration rate is 27 times larger than it is in Brandenburg. The cause cannot lie with different weather or with a higher proportion of combined sewer systems in Hessen.

Even though some of the numbers illustrated in Figure 6 may be doubted, the overall picture is still alarming. With the high rate of connection to the sewerage, and with the extensive further construction of rainwater treatment plants, I/I-water has now become a new and serious problem. It will never be entirely possible to avoid infiltration water, and the DWA-M 182 leaflet [15] deliberately does not set a maximum limit – although mean annual I/I-rates of more than 50 % indicate a serious need for action!

9 Growth of rainwater treatment

The growth in the number of stormwater facilities over the 40-year period from 1975 to 2015 is illustrated in Figure 7. Satisfactory data sources for the whole country have only been

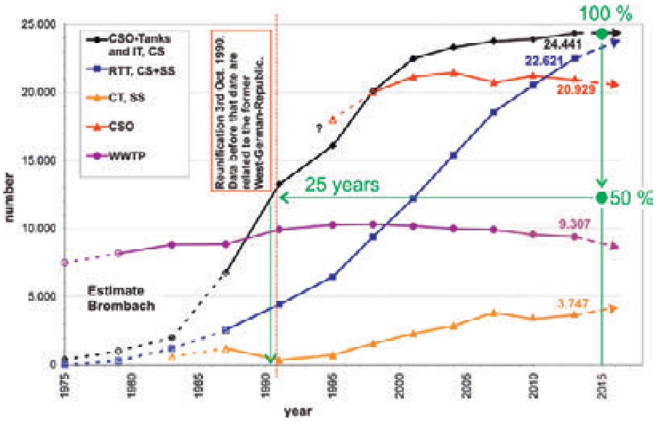

Fig. 7: Growth in the number of stormwater facilities, report year 2013

available since reunification. The earlier period has been reconstructed from sources [1–3]. The figures for later than the report year 2013 are estimated.

9.1 Combined sewer overflow tanks and combined inline tanks with overflow

According to the official figure, there were 24,441 combined sewer overflow (CSO-tanks) and combined inline tanks (IT), with a total volume of 15,078 million cubic metres, at the end of 2013. The mean volume of each tank was 617 m³. As can clearly be seen in Figure 7, the period from 1987 to 1998 was a phase of vigorous construction of stormwater tanks. Only a further 561 stormwater tanks have been added in the whole of Germany since report year 2010. The phase of new construction of this type in the combined system is largely completed.

It must not, however, be overlooked that about half of the stormwater tanks presently in use are more than 25 years old! Many of the old tanks no longer correspond to today's regulations and understanding, and about 40 % of all stormwater tanks, which is nearly 10,000 of them, have an abnormal overflow frequency [16]. In many cases, spare parts are no longer available for the technical equipment, and in particular for the electronic controllers. The second phase of the central rainwater treatment in the combined system, the renovation (upgrading) and optimisation of existing constructions, is already in full swing.

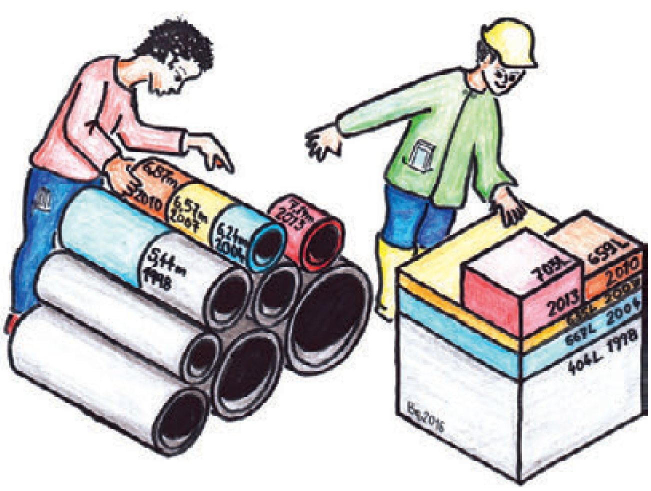

Fig. 8: Mean sewer length per inhabitant and mean retention volume per inhabitant for stormwater discharges, report year 2013

9.2 Stormwater retention tanks

A total of 22,621 stormwater retention tank (RTT) is given for the end of report year 2013. 2140 structures have thus been added since 2010. In terms of simple numbers, the stormwater retention tanks are similar to the stormwater tanks with overflow. With a volume of 39,004 million cubic metres, their storage capacity has now more than overtaken the combined sewer overflow tanks! The average storage capacity of each stormwater retention facility, at 1,724 m³, is almost three times as great as that of the stormwater tanks with overflow.

A steady upward trend can be seen in the RTT curve in Figure 7. A further increase in residential and traffic areas is leading to an increase in the need for stormwater retention facilities. This applies both to the construction of state and federal roads and to motorways, whose drainage systems include appropriate stormwater retention facilities. These installations, whose numbers and volumes are altogether quite significant, are not, however, recorded by the Federal Statistical Office. They are not assigned to the "public wastewater disposal", which is restricted to municipalities and water associations with special legal status.

9.3 Stormwater clarifier tanks

The 3747 stormwater clarifier tanks (CT) in the storm sewers of the separate system means that they are relatively rare. The "bump" in 2010 is most likely due to a change in the method of counting. The mean volume of the stormwater sedimentation tanks is 687 m³. There is a question as to whether the stormwater sedimentation tanks in the drainage system outside of the municipalities and association areas – see Chapter 9.2 – have in fact been included in the data collection.

9.4 Combined sewer overflows

The stormwater overflows in the combined system (CSO) have only been recorded statistically since 1998. 20,929 of them were in operation at the end of 2013. 170 stormwater overflows have been decommissioned since 2010. This is consistent with current trends.

9.5 Public wastewater treatment plants

The number of public wastewater treatment plants (WWTP) with a total number of inhabitants and population equivalents of more than 50 in Germany reached a maximum of 10,312 in 1998, and then dropped slowly but continuously back to the present figure of 9,307 in 2013; see column 22 in Table 1. The wastewater from 96.7 % of all inhabitants is treated in central wastewater treatment plants, corresponding to a federal average of 8.373 inhabitants for each wastewater treatment plant [10].

The incorporation of multiple small treatment plants into larger wastewater treatment plants is a reasonable trend which should continue, or even be reinforced, since, in contrast to the global trend, wastewater treatment plants of small to medium size still dominate in Germany.

10 Current technical regulations

In November 2013 the DWA published what is known as the "Combination Package for Central Stormwater Treatment" [14, 17, 18]. It replaces and extends the old ATV-A 166 worksheet from 1999 and the ATV-DVWK-M 176 worksheet from 2001.

In parallel with this, and in mutual agreement with the expert panel of the DWA, the suppliers organised into the VDMA (Verband Deutscher Maschinen- und Anlagenbau – German Engineering Association) developed a standards sheet [19] covering the operation, maintenance and renovation of the engineering equipment of stormwater tanks. It appeared in October 2012.

This means that a modernised and comprehensive set of regulations for the planning, design, technical fitting and operation, maintenance, optimisation and renovation (upgrading) of central stormwater tanks is now available for planners, regulatory authorities, operators and suppliers. The most important innovations, which are included in both the DWA's combination package and in the standards sheet from the VDMA, are the introduction of the "functional test" and the subsequent "trial operation" for a period of between three and six months.

The German regulations above have also attracted attention abroad. In Switzerland, the VSA (Swiss Water Pollution Control Association) issued a technical guideline [20] in April 2013, which had adopted a large number of ideas, and even drawings, from the German regulations. In Spain, the Ministry for Agriculture, Food and the Environment published in national manual with recommendations for the design of stormwater tanks [21] in September 2014, in which examples of German stormwater technology are reproduced. In its regulation sheet 19 [22], the Austrian Water and Waste Management Association (ÖWAV) referred to DWA-A 166 and DWA-M 176 in respect of the structural design, servicing and operation of installations.

Stormwater tanks are even today dimensioned in accordance with the ATV-A 128 working sheet, originally published in 1977 and last revised in 1992. A replacement for these old dimensioning rules, which at their heart are about 39 years old, is underway, and should be made available shortly in the entirely new DWA-A 102 working sheet.

11 Conclusion and outlook

In December 2015, the German Federal Statistical Office presented, in the 2.1.3 series, new and now complete official data relating to the type and scope of public municipal sewage system and rainwater treatment in Germany for report year 2013.

In the middle of 2013, the population had dropped back to 80,586 million (2010: 81,751). Today's flow of refugees was yet to make itself felt. By the time of the next census by the Federal Statistical Office in 2015, the population will have grown again, and the specific figures, such as the number of metres of sewer or the storage volume per inhabitant, will fall. What will happen to the mean consumption of drinking water, which was 121.1 litres per inhabitant and day in 2013?

In the middle of 2013, the proportion of the population of the federal republic connected to the public sewerage stood at 96.9 %. The new federal states still have a small backlog. The federal average was 7.14 m of public sewer per citizen (Figure 8). The proportion of citizens connected to combined sewer systems, measured from the ratio of the drainage lengths of the combined and sanitary sewers, has fallen again, now standing at 54.1 %. The ironically named "German combined water equator" has again moved slightly southwards.

In 2013 Germany had in total an impressive 50,809 stormwater tanks, with a total volume of 56.658 million cubic metres. 0.703 m^3 per inhabitant of storage volume for the retention of rainwater was present (Figure 8).

The federal average for 2013 of the infiltration / inflow rate had an annual mean of 44.5 %. The high level of I / I-rate – more than 50 % in five federal states – is alarming. There is a need great for action, to standardise infiltration water statistics valid across the country.

The number of public wastewater treatment plants (WWTP) in Germany has fallen slowly but continuously since 1998, dropping to 9,307 in 2013. This is a plausible trend.

The retention soil filter basins (SRSF), of which the author estimates there must already be some thousands, are unfortunately entirely missing both from the statistics of Table 1 and from Figure 7. The data has not yet been collected. Many stormwater tanks on state and federal roads and on motorways are not categorised as "public wastewater treatment", and until now have not been included in the federal statistics. Both these gaps in recording should be closed as soon as possible.

The first phase of stormwater treatment in the combined system is largely concluded, and there will only be a few new constructions. The second phase of the central rainwater treatment in the combined system, the renovation (upgrading) and optimisation of existing constructions, is already in full swing.

The DWA and VDMA engineering regulations for the structural design and equipping of buildings for central stormwater treatment were updated in the years 2012 and 2013.

Reliable information relating to the effectiveness of stormwater tanks with overflow and sewers with storage capacity and overflow is so far only available for very few installations. The installation, operation and maintenance of powerful machines, instrumentation and control apparatus is necessary to record the relevant material and volume flows, and for the sake of potential plant optimisation. On top of this, the data must be analysed promptly and with the proper expertise.

Since, even at the beginning of the second management plan in the context of implementing the European Water Framework Directive, our surface waterways are only in good condition in a few cases, research into the causes has special importance. Although past decades have seen high investment made for the construction of stormwater treatment installations, the absence of knowledge about their real effectiveness means that in many cases reliable conclusions cannot be drawn as to whether and to what extent relief from the sewerage sector is (partly) responsible for the failure to reach a good water quality status.

Acknowledgement

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State of the Sewer System in Germany*)

Results of the DWA survey 2015

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Since 1984/85 the German Association for Water Management, Wastewater and Waste (DWA) has regularly carried out surveys on the state of the sewerage in Germany. This survey is currently the seventh of the series. The objective is to collect the most representative possible picture of the state of the sewerage in Germany. 339 sewerage system operators from all parts of Germany took part in the survey. They represent 22.56 million inhabitants, corresponding to 27.9 % of the total population of Germany.

Current data from the Federal Statistical Office is available on the length, year of construction and type of the public sewerage. The total length of the sewerage in Germany grew from 561,581 km in 2010 to 575,580 km in 2013. This corresponds to a growth of 2.5 %. In total, the length of the sewerage has grown by 176,359 km since 1995 – this is about 10,000 kilometres per year (Figure 1).

Of this increase, 29,372 km represents an extension of the combined network, 96,862 km represents an extension to the sanitary sewage network, and 50,144 km is an extension of the stormwater network. The reasons for the growth are to be found primarily in the increasing further development of existing combined and separate systems, along with the conversion of existing combined systems into separate systems. In addition to this, the construction of high-level traffic routes, together with an expanded knowledge of sewers that already exist and that have been found in the course of the continuing registration of the state of the sewerage and added to the inventory databases, represent subsidiary reasons for this rise.

The median of the public sewerage system length of the cities and municipalities who took part in this survey was 8.34 m per inhabitant, and is thus somewhat lower than the mean value of 9.31 m per inhabitant.

Age of the sewerage

Taking the lengths associated with the respective age classes into account, a figure of 39.8 years results for the average network age for the participant's sewerage. In communities with a population of less than 10,000 P, more than 45 % of the network is less than 25 years old, the mean age being 25.5 years. The average age of the sewerage rises with increasing size of the cities and municipalities. Finally, in large cities with more than 250,000 inhabitants, more than 40 % of the sewerage system is more than 50 years old. The average age of the sewerage system here is 50 years. It is not, however, possible to draw conclusions about the condition of the network or the need for rehabilitation on the basis of age alone since, for example, brickwork sewers with an age of more than 100 years are often still in very good condition.

Material distribution in the sewerage

The proportion of stonework and concrete rises with increasing size of the cities and municipalities. Precisely the opposite is true for plastic pipes. Whereas the proportion of plastic in the sewage systems of communities with less than 10,000 inhabitants is 18.4%, it is only 5.5% in large cities with more than 250,000 inhabitants. It is possible that on the one hand there is a relationship between the age structure and the distribution of materials, since in smaller communities the sewerage system is often newer, and the use of plastics has only increased in recent decades. On the other hand, sewers with a small diameter, which are increasingly found in small local authorities, are often made of plastic. The high proportion of other, or even unknown, materials in municipalities with less than 10,000 inhabitants is also noticeable. This proportion also falls as the size of the community grows. An extrapolation from the material distribution indicates that the largest proportion of the sewerages, with a figure of 38.4 %, is made of concrete. The

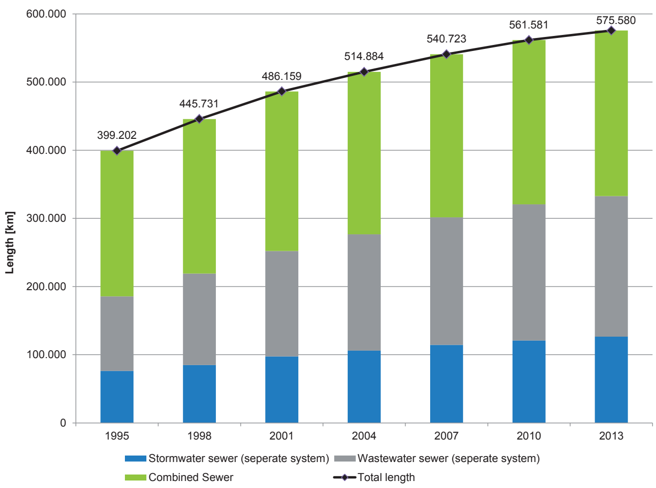

Fig. 1: Change in the length of the sewerage system in Germany (1995–2013)

*) The full evaluation of the survey was published in German in *KA Korrespondenz Abwasser, Abfall* 2016, *63* (6), and can be downloaded from the internet at: *http://de.dwa.de/umfrage-zum-zustand-der-kanalisation-in-deutschland-5209.html*

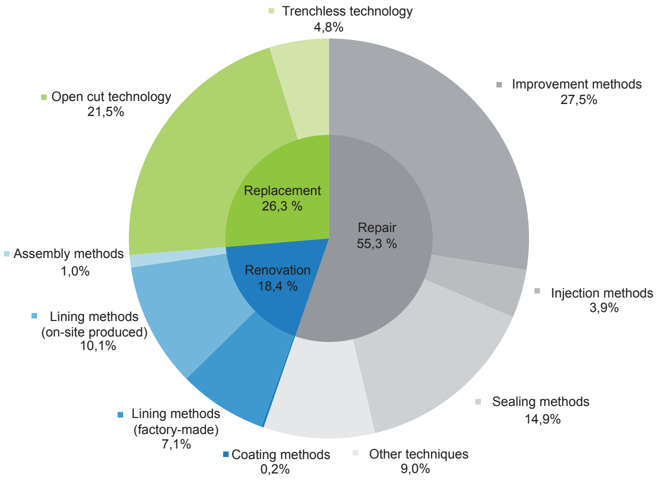

Fig. 2: Distribution of rehabilitation methods (n = 194; Σ = 85,289 km)

proportion of stonework comes next, at 31.0 %. 16.3 % of the sewerage system in Germany is made of plastic.

Description of the condition of the sewerage

The distribution of damage in the wastewater drains and sewers was questioned in the survey. 218 sewerage system operators provided answers. The most frequent types of damage were those of "protruding or faulty connection" (21 %) followed by "crack formation" (19 %). Sorted according to frequency, the damage classes of "connection (displaced or protruding gasket)" (13 %), "flow obstacles (roots, deposits)" (11 %) and "surface damage (including corrosion and abrasion)"(10 %) followed. The average faulty length per reach reported by the survey participants was 5.42 m; the average number of defects in each reach was 3.5.

Description of the condition of manholes

The degree of recording and knowledge of the structural condition of manhole structures is significantly lower than the knowledge over reaches. The evaluation of the distribution of defects at manholes (n = 208; Σ = 1,809,861 shafts represented) leads to the result that damage to the covers and frames of the manholes (26 %) continues to be the most frequent cause of damage. This is followed in frequency by damage to the climbing aids (22 %) and the connections (12 %) to the manholes. The faults of "infiltration/exfiltration/protruding sealant material)" and "formation of cracks" are each assigned 9 % of the total damage to manholes.

Need for rehabilitation

The results of the survey indicate that the proportion of reaches in condition classes 0 to 2, and which thereby have a need for rehabilitation in the short-to-medium term, was 23.8 % amongst those sewage network operators who took part in the survey. If this proportion is transferred to the data from the Federal Statistical Office on the distribution of local authority sizes over the whole of Germany, a proportion of 19.4 % results.

Rehabilitation methods

In the most recent collection of data, the relining method, at 93.5 %, remained the most frequently used method of renovation. The current distribution of rehabilitation methods used in Germany by participants in the survey in 2013 can be seen in Figure 2. Over the data collection period of the current survey, a total proportion of 5.5 % of the sewerage system was renovated, corresponding to an annually renovated proportion of 1.1 %, or 6,331 km of sewerage system.

It is clear that the proportion of rehabilitation done by replacement continues to fall. The proportion of the renovation method, at just under 20 %, remains almost the same. The high proportion of repair methods, which, at 55.3 %, make up the major part of the rehabilitation methods, is noticeable. At 49.8 %, the mending method is the most frequently used repair method.

Investment in sewer rehabilitation

As in previous surveys, the investment in rehabilitation was questioned. The results of the previous and current surveys are collected in Table 1.

It can clearly be seen that the costs per metre of sewer rehabilitation are low for the methods grouped under "repair", and have fallen considerably for those methods grouped under "renovation". The costs for renewals on the other hand have hardly changed. Possible causes for the marked reduction in the price per metre for renovation methods include further development of the renovation technologies, associated with an increase in the efficiency as well as, in some cases, a change in

		Rehabilitation costs [€]	Length [km]	Costs [€ per m]	Kilometres of network represented	Number of communities
Repair	2004–2008*)	71 202 284	549	130	31 994	36
	2009–2013	208 547 641	1 852	113	53 453	106
Renovation	2004–2008*)	312 798 892	404	773	40 019	37
	2009–2013	302 507 583	734	411	56 231	97
Replacement	2004–2008*)	1 188 111 147	778	1526	43 540	42
	2009–2013	1 311 741 035	828	1584	60 585	104

*) Condition of the sewage system – results of the DWA survey 2009, *KA* 1/2011, 24–39

Table 1: Rehabilitation costs

the nominal diameters of the renovated sewers. Related data was, however, not requested in the survey.

Length of the private drainage system

The length of the private sewerage system is often estimated to be several times the length of the public sewerage system. The overall length of the house-drainage systems was asked for in this survey in order to update these estimates. On the basis of the responses from 27 sewerage system operators who provided information on the length of the house-drainage systems, both a median and a mean value for the ratio to the length of the respective public sewerage system of about 2 is found. Extrapolating from this, the current total length of the house-drainage systems in Germany can be calculated to be around 1.1 million kilometres.

Conclusions

The survey shows that very extensive knowledge of the condition of the public sewerage is available in Germany, and that sewer management in terms of value retention and maintenance of operational capability is comprehensively implemented. Nevertheless, about one fifth of all sewer reaches have damage that must be rehabilitated in the short-to-medium term. The results of this survey thus also indicate a high need for investment for the sustained management of the “invisible” infrastructure of residential settlement drainage. It is necessary that rehabilitation strategies that either exist or require preparation are implemented in order to counter long-term erosion of the assets of the public sewerage system. This requires those municipal decision makers to be provided with information and to be alerted to the issue.

The average age of the sewerage in Germany is below 40 years. Concrete and stonework are the most frequently used materials. The proportion of plastic pipes continues to rise. The proportion of rehabilitation methods involving renewal continues to fall; the proportion of repairs is increasing, the proportion of renovation methods is unchanged. A total of 1.1 % of the sewerage system in Germany is rehabilitated annually.

The level of knowledge regarding the condition of house-drainage systems is still low. Extrapolation gives an overall length of about 1.1 million kilometres for house-drainage systems in Germany. Most citizens are able to obtain advice relating to the registration of the condition and the rehabilitation of their house-drainage system through the operator of the public sewerage.

Acknowledgement

At this point we would like to thank everyone who has made this assessment possible through taking part in the survey.

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27th Performance Comparison of Municipal Wastewater Treatment Plants in Germany

Demographic Change

1 Aims, principles and limits of the federal performance comparison

The performance comparison of the German Association for Water Management, Wastewater and Waste (DWA) presents the quality of wastewater treatment and the electricity consumption used for the purpose. The performance comparison reflects the qualified work of operating personnel, who should be appropriately acknowledged here. The data for this performance comparison was collected and evaluated by the DWA federal state associations.

According to the Federal Statistical Office, the proportion of the population connected to municipal wastewater treatment plants was 95.6 %. Out of the total of 9,632 municipal wastewater treatment plants in Germany, with an installed capacity of 152.1 million PT, 5,776 wastewater treatment plants, with an installed capacity of 140.4 million PT participated in the 27th DWA performance comparison. With a participation rate of 92.3 %, the results for 2014 can be considered representative for Germany. The more than 3.6 million individual measurements taken by operating personnel in the context of self-monitoring, and which are incorporated in the evaluation as mean annual values, provide the foundation.

As in the past, the evaluation is divided according to DWA federal state associations, and according to a size range (SR) of the wastewater treatment plants. The distribution of wastewater treatment plants across installed size and number is shown in Fig. 1. While only 4 % of the wastewater treatment plants have a size greater than 100,000 PT (SR 5), these plants at the same time represent 52 % of the total installed capacity.

2 Results

The results of the feed and discharge measurements (freight-weighted mean values), the degree of degradation, further parameters, and information regarding participants are assembled in Table 1. As in the previous year, the results of the Austrian Water and Waste Management Association (ÖWAV) comparison of the performance of wastewater treatment plants for the installations in Austria and South Tyrol are also shown.

This time, however, only municipal wastewater treatment plants, with an installed capacity of 21.6 million PT, have been evaluated.

In contrast to the previous year, the federal average of the discharge concentrations for total phosphorus, total nitrogen and NH4-N shows small improvements, although the degree of degradation on the other hand shows slightly lower values. This is presumably a result of the heavier rainfall in 2014. The higher degradation levels for nitrogen and phosphorus in the federal state associations of the North and North East, which are caused by the markedly higher concentrations in the feed, are notable.

The separate systems, which are more widespread in these federal states, may be amongst the reasons for this.

On the whole, as a federal average, it was possible to meet or significantly exceed the requirements of the EU Urban Waste Water Treatment Directive, again in 2014. It is still nevertheless necessary for some installations (sewerage system and wastewater treatment plants) to be brought up to the present state of the art.

The mean loading of the installations in PT was determined from the mean COD freight inflow as a reference magnitude for calculating the specific wastewater generation and the specific electricity consumption. A specific COD freight of 120 g/(PT·d) was assumed here.

In comparison with the previous year, the specific wastewater generation showed a significant rise in those federal state associations where combined sewer systems are primarily used, again as a result of the higher levels of precipitation. In the North and North East federal state associations, the specific wastewater generation figure was significantly lower.

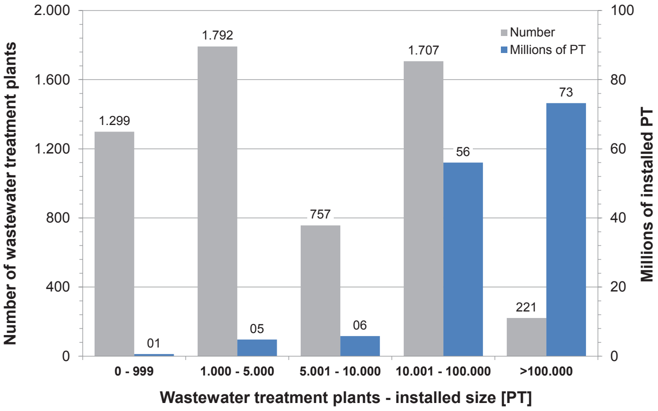

Fig. 1: Wastewater treatment plants participating in the 2014 DWA performance comparison

DWA Federal state association		Baden-Württemberg	Bavaria	Hessen/Rhineland Palatinate/Saarland	North	North East	North Rhine-Westphalia	Saxony/Thuringia	DWA	ÖWAV*
Wastewater treatment plants (number)		938	1653	1395	481	301	495	513	5776	871
Annual sewage amount (millions of m³)		1,538	1,442	1,469	752	481	2,237	449	8,369	1,130
Installed quantity of PT (millions of PR)		21.5	27.3	18.2	20.3	12.8	31.9	8.5	140.4	21.6
Mean PT loading (millions of PT)		15.4	19.1	15.6	15.2	12.2	21.6	6.5	105.5	14.2
Installed PT/mean PT loading		1.40	1.43	1.17	1.34	1.05	1.48	1.31	1.33	1.52
Specific sewage flow [m³/(PE*a)]		100	75	94	49	39	104	69	79	80
Specific energy consumption [m³/(PT*a)]		34.2	32.0	30.3	32.6	28.7	35.3	34.0	32.6	29.6
COD	Inflow (mg/L)	437	579	468	887	1109	424	646	554	549
	Discharge (mg/L)	20	29	22	39	41	25	30	27	27
	Degree of degradation (%)	95.4	95.0	95.3	95.6	96.3	94.1	95.4	95.2	95.1
Total nitrogen**)	Inflow (mg/L)	41.3	51.1	45.5	73.5	100.9	40.7	61.7	51.0	43.9
	Discharge (mg/L)	9.1	9.6	8.5	9.0	11.0	6.9	10.0	8.7	8.0
	Degree of degradation (%)	78.0	81.2	81.3	87.8	89.1	82.9	83.7	83.0	81.7
Total phosphorus	Inflow (mg/L)	6.4	8.4	6.9	12.1	16.8	6.0	9.6	8.0	6.7
	Discharge (mg/L)	0.58	0.93	0.83	0.65	0.62	0.47	1.00	0.69	0.67
	Degree of degradation (%)	91.0	88.9	88.0	94.7	96.3	92.2	89.7	91.5	90.0
NH_4-N	Discharge (mg/L)	0.58	1.41	1.46	1.15	0.86	0.77	1.33	1.04	1.28
NO_3-N	Discharge (mg/L)	7.2	6.4	5.3	5.8	8.2	4.9	6.7	6.0	5.7

* Austria and South Tyrol (operation year 2014, municipal wastewater treatment plants only, i.e. without industrial treatment plant)
** Total nitrogen = $N_{inorganic} + N_{organic}$

Table 1: Mean feed and discharge values, degrees of degradation and parameters

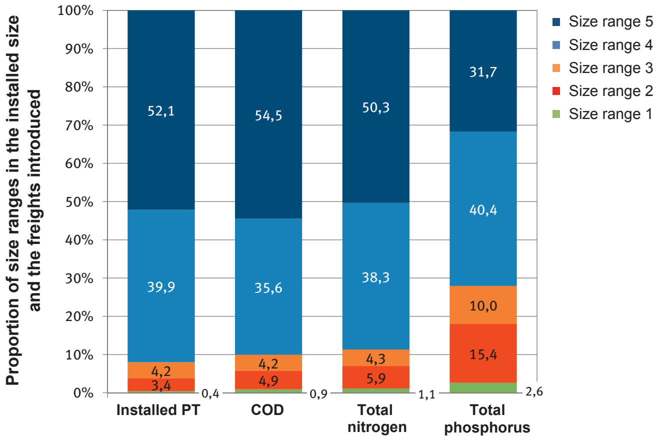

Fig. 2: Percentage proportions of the installed PT and the introduced freights according to wastewater treatment plant size ranges

Electricity consumption, likewise, was deducted in all federal state associations. It was possible to calculate the specific electricity consumption (kWh/(PT·a)) for 5,165 wastewater treatment plants. There is only a small difference between the specific electricity consumptions between the federal state associations. The lowest values were found for Austria/South Tyrol, the federal state associations of Hessen/Rhineland Palatinate, Saarland, Bavaria and North-East, while the highest values were found in North Rhine Westphalia and Baden-Württemberg.

The COD freights and total nitrogen freights introduced into the waters correspond largely to the respective proportions of the installed sizes grouped into size ranges. Plants in size ranges 1 to 3, however, have an above-proportional share of phosphorus at about 28 %, although, taking their installed size into account, these plants only represent a proportion of 8 %. Since the collection quota in the performance comparison is lower than the data from the Federal Statistical Office for size ranges 4 and 5, the proportion of freight actually introduced may in fact be higher. The cause for the high proportion in size ranges 1 to 3 are those plants which, due to an absence of statutory requirements, do not have to carry out any specific measures for phosphorus elimination. This can in particular be a problem for waters in which the water flow is low, as it means that the requirements for the phosphorus concentration in the waters for the very good ecological condition according to the surface water regulations cannot be met.

3 Demography

In some regions it is above all demographic change, alongside climate change, tightening ecological requirements (extensive nutrient elimination, hygiene, trace substances, microplastics, etc.) and the protection and recycling of resources (phosphorus and energy above all) that present the greatest challenge to the infrastructure systems for sanitary environmental engineering. The extent to which changes in population and the economy affect the cleaning performance of the wastewater treatment plants can be examined with the help of the many years of data in the performance comparison. The possible effects can be presented taking the example of the Spree-Neiße administrative district, which is the one most affected in the North-East federal state association, where the population fell by 17 % between 2002 and 2013 (Federal Statistical Office). The COD freight inflow, which has been recorded since 2002, continues even now to show a falling tendency from 5,000 t to a present value of 3,500 t. This corresponds to a drop of about 34,000 PT (assuming a specific COD freight inflow of 120 g/(PT·a)). Over the same period, the population fell by almost 20,000 inhabitants. The greater fall in the COD freight can be traced back to a reduction in the industrial wastewater generation paralleling the population figure. The COD discharge values varied between 29 and 36 mg/l, while the efficiency is almost unchanged at about 97 %.

Over the last two years, the total nitrogen figure in the discharge rose slightly from 5 mg/l to 7 mg/l. It is not, however, possible to recognise a clear trend that could be traced back to the lower loading figures.

This means that the many years of performance comparison data provide no evidence for a direct effect on the discharge figures and degree of degradation as a result of democratic change at the district level. Direct considerations of individual cities and localities may yield more interesting conclusions.

The performance comparison data considered shows that a consideration of the long-term development of the loading relationships is necessary for a realistic assessment of plant capacity, in particular when more extensive renewal measures are to be taken.

4 Summary

It was possible to keep participation in the Germany-wide DWA performance comparison at a high level in 2014 again. We would like to offer our sincerest thanks to the operating personnel at the municipal wastewater treatment plants. The results provide a representative picture of the cleaning performance of wastewater treatment plants in Germany. In 2014,

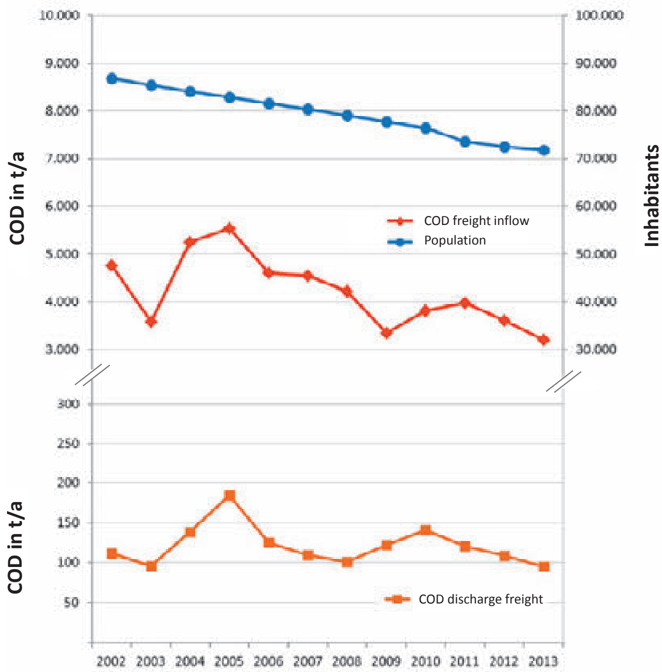

Fig. 3: Change in the population figure and COD freights in the feed and discharge in the Spree-Neiße district

5,776 wastewater treatment plants, with a total installed capacity of 140.4 million PT, took part. As in the previous year, the corresponding data from ÖWAV for Austria and for South Tyrol are included for comparison. The results correspond largely to the data for German wastewater treatment plants.

On the whole, as a federal average, it was possible to meet or significantly exceed the requirements of the EU Urban Waste Water Treatment Directive, again in 2014. Whereas there are no great differences between the various size ranges in respect of the COD and the total nitrogen degradation degree, the phosphorus elimination of wastewater treatment plants whose installed size is less than 10,000 PT was significantly inferior. These wastewater treatment plants represent a proportion of about 8 % of the total installed capacity, but are responsible for about 28 % of the phosphorus freight introduced into the waters. The cause for this lies with those plants which, due to an absence of statutory requirements, do not have to carry out any specific measures for phosphorus elimination.

It is still necessary for some installations (sewerage system and treatment plants) in all size ranges to be brought up to present technical standards. In future, more attention should also be paid to the treatment of combined wastewater.

The electricity consumption of wastewater treatment plants throughout the country was also collected and statistically evaluated. The mean specific electricity consumption was found to be 32.6 kWh/(PT·a). At present, private electricity consumption is somewhat more than 1,000 kWh/(PT·a). It is therefore clear that less than 4 % of the annual electricity consumption of household (or inhabitant) is required for wastewater purification. The aim of wastewater purification is to achieve the highest possible level of purification in combination with a low expenditure of energy. It is therefore obvious that the wastewater treatment sector is no exception to the need not to waste energy. By means of an energy check and an energy analysis, it should in future be possible to evaluate the electricity consumption for wastewater purification correctly, to identify unnecessary excess consumption, and to introduce measures to achieve energy-efficient operation.

A further, general need for action in respect of wastewater treatment plants may be triggered in coming years as a result of statutory requirements for the construction of a fourth purification stage to remove trace substances from the waste water. Extensive research is at present being undertaken in this field.

Demographic change is seen in the example of the strongly affected Spree-Neiße administrative district, where the population has fallen by 17 %, entailing a correspondingly falling COD freight in the feed to the wastewater treatment plants. The purification performances of the wastewater treatment plants considered have nevertheless not changed significantly.

The working group DWA BIZ-1.1 Neighbourhoods, would like to thank all the participants, teachers and representatives of the wastewater treatment plant neighbourhoods for their support in the collection and evaluation of the data, without which this country-wide performance comparison would not be possible. The 27th performance comparison – based on the data for 2014 – is also available from the DWA website (*www.dwa.de*) free of charge by selecting "Events – Neighbourhoods – Further information" from the menu.

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The Worldwide Search for Best Practices by Benchmarking Programmes of the Water Sector

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Benchmarking is a management tool which is well-established in the water sector since its first occurrence in the early 1990s. Worldwide hundreds of initiatives, programmes and projects can be counted. Some of them are listed in this article to explain the current status of practice. The long term use has neither led to a consistent terminology on benchmarking nor to a consistent practice. Nonetheless, the goals connected with benchmarking in the different programmes can unanimously be described with performance assessment, performance improvement and also public communication. But not all programmes have the same focus. It must be made clear, that when speaking about a management tool facilitating learning and improvement (mostly found in industry-based approaches) and when speaking about a tool to increase transparency and governance, the two rationales are very different.

The authors of this article work for the German industry-based approach of benchmarking. Their understanding is confronted with the appliance of benchmarking in other programmes. Hereby, the success factors of benchmarking as a tool to discover good practices are shown. The industry-based approach of benchmarking has started on a national level, but soon was transferred also across the borders. An invitation of German operators to European operators is given to work with such methods on an international level.

1 Introduction – Wide Variety of Benchmarking Programmes in the Water Sector since the 90s

Benchmarking is a management method that has spread throughout a wide array of sectors since the late 1980s. Credit for the description of the idea and concept of benchmarking is mainly given to two American publications [1, 2]. In both cases benchmarking is seen as a tool to identify best practices used by partners or competitors. The method has been promoted since then. A recent publication [3] counts on average 350 publications each year between the period 1993 to 2004 and cites studies from 2009 in which benchmarking is ranked by 9,000 managers as the most-used management tool. A survey [3] among 450 organisations predicts that it will also continue to be the most-used tool in the future.

In the water sector the first benchmarking projects started in the early and mid-1990s [4]. Today, the sector has ample experience in benchmarking. A review (International Benchmarking Review by WRc, in [5]) identified about 160 benchmarking initiatives in the global water sector in 2001[1)]. Programmes and activities are differentiated as follows:

- ***National industry-based programmes*** are initiated by the water operators or industry themselves and are run voluntarily and organised by industry associations, consultants or operators (or through a cooperation among these parties). Such programmes exist in most European Countries, Canada and Australia but also in newly industrialised and developing countries. Leading programmes are selected for this article:
  - aquabench GmbH in Germany was founded in 2003 by German and Swiss operators (*www.aquabench.de*). It is the biggest consultant for benchmarking programmes in the German water sector and represents experiences which operator have made with benchmarking since 1996. German benchmarking programmes are run on base of defined understanding of benchmarking by technical rules of the industry associations [6].
  - National Water & Wastewater Benchmarking Initiative (NWBBI) in Canada is an initiative of operators, run by a consultant in close cooperation with operators. It has a strong history in developing learning and improvement tools.
  - The South African Local Government Association (SALGA) runs a programme for all municipalities in South Africa (Municipal Benchmarking Initiative) and is a successful example of an industry-based approach in developing countries.[2)]

1) [5] provides a general overview of activities for Latin America, Africa, Asia and OECD countries based on a study for the World Bank. [7] compares the work of 18 regulatory agencies from developed and developing countries. For Europe [30] has given recently a rough overview of some benchmarking activities in European countries (which nonetheless is far from complete).

2) Additional programmes from developing countries, initiated by industry associations, are known to the authors from Kenia and Arab countries.

- ***Regulatory benchmarking programmes*** are initiated by regulatory authorities to assess and improve quality of service or to support economic regulation. Such programmes are mandatory. [7] concludes in a survey of regulatory practice, that 95 % of regulators use performance indicators for assessment, often described as "benchmarking". Relevant examples to describe such practices are:
  - Ofwat, the water services regulation authority for England and Wales is considered by some authors to be one of the first institutions to introduce assessment by performance indicators in the water sector [8]. The regulator has a strong history in different and varying applications of benchmarking.
  - Mandatory benchmarking in the Dutch water sector is an example of collaboration between operators and ministry entities. The operators had been conducting voluntary benchmarking since 1997, however, since the Dutch Water Act in 2010 utilities have to participate in mandatory benchmarking which is partly based on the voluntary programme; these results are published [9].
  - ERSAR, the regulating authority for water services and waste disposal in Portugal, has been using performance indicators to formulate and assess water sector objectives since 2004.
- ***International associations and organisations*** summarize and support benchmarking programmes:
  - In 1997, the International Water Association (IWA) established a PI taskforce. Its final output, the IWA PI systems for water supply services [8] and for wastewater services are likely to be the most widely used references in their field today. Among many other applications, these systems are the basis for the regulatory PI system of ADERASA in South America, the framework for voluntary benchmarking of water supply in Germany, the quality of service regulatory system established in Portugal, the Japanese PI system of the Japanese Water Works Association, and the water losses PI of the American Water Works Association [8]. The conference series from the IWA Specialist Group on Benchmarking and Performance Assessment summarises international experiences and developments since 2008 [10]. Relevant IWA publications summarise worldwide trends [8, 11].
  - [12] summarises sources on international activities in the water sector and provides data of more than 135 countries and more than 4,400 operators.
  - ISO Technical Committee 224 published a series of standards on objectives and performance assessment of water services, among others using performance indicators [13]. Currently, the Committee is also working on a standard for benchmarking in water services.
- Additionally, **international benchmarking programmes,** initiated by operators and the industry, have been started in recent years (see chapter 4).

This article compares the different focus of the practical programmes, by showing that all programmes are focusing on performance assessment, performance improvement and public information, but using very different tools to reach these goals and having a very different understanding of benchmarking. Tools and success factors to reach performance improvement in industry-based programmes are summarized and an invitation to participate in international activities of such programmes is given.

2 Differences in the Understanding and Practices of Benchmarking

2.1 Theoretical Concepts

Authors of the International Water Association rightfully point out that nearly 20 years of activities in benchmarking and subsequent publications have led to a "sometimes confusing terminology" on benchmarking and its various concepts [8, 14]. This is primarily attributed to the fact that different academics, consultants, and regulators employ different terminology to classify benchmarking methods. In particular, the difference between metric benchmarking and process benchmarking was never unanimously understood in the various publications, leading to variations in language on benchmarking methods[3]. In fact, the theoretical discussion regarding terminology reflects real differences in the practice of benchmarking. One particular feature can be identified across all industries:

"One of the common problems is that many people consider benchmarking to be solely about comparison rather than learning from the practices of other organisations and adapting and implementing these practices." [3].

"Metric benchmarking" is often associated with the comparison of measurements and results, whereas "process benchmarking" is considered to relate to "adaption of best practices" and "learning" (in some understanding even without considering metric, or quantifiable, measures.). In this sense, such classifications correctly encompass existing methods. However, such distinctions seldom exist in reality – most process benchmarking rely on the use of indicators (metrics) and the application of metrics in metric benchmarking is often aimed towards improvement.

The IWA Specialist Group on Benchmarking and Performance Assessment recommends abandoning the above classifications and propose a simpler concept of benchmarking methods [14]:

"Benchmarking is a tool for performance improvement through systematic search and adaptation of leading practices."

When summarising the discussion on metric and process benchmarking, they conclude:

"The IWA Specialist Group on Benchmarking strongly recommends abandoning the use of the terms 'metric benchmarking' and 'process benchmarking'. Instead "performance assessment" and "performance improvement" should be considered consecutive components of benchmarking."

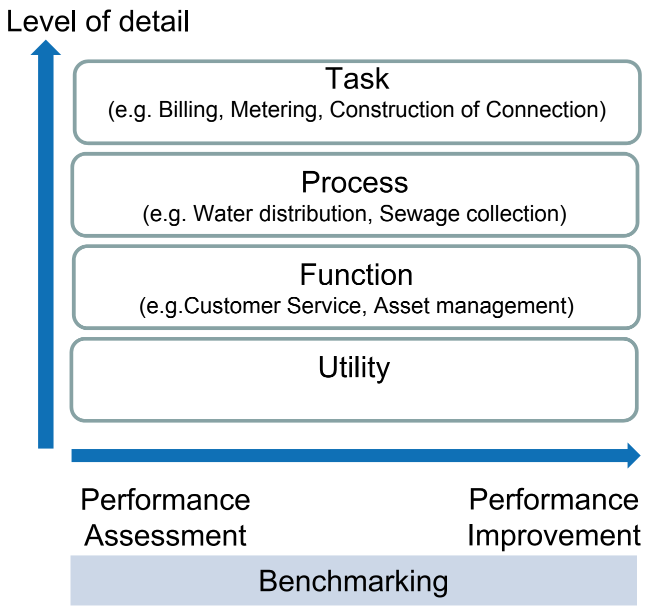


Fig. 1: Performance assessment and improvement model [14]

The German associations have worked in the same direction, when formulating technical rules on benchmarking [6].

To illustrate this understanding a "performance assessment and improvement model" was developed (Figure 1). The IWA model [14] clearly points out that the performance improvement is essential in benchmarking. All programmes should reflect how performance improvement is achieved through the use of their methodology. But the model also helps understand and classify existing methods and programmes. The above mentioned metric benchmarking is focused mainly on "performance assessment" and "at the utility level". Process benchmarking has stronger focus on "performance improvement" at the process level.

Most benchmarking programmes are ultimately used to improve the sector, so although the main focus of their work and activities is on performance assessment, the model should not be used to deny the programmes the "title" of benchmarking. In fact, differences can be rather discerned differentiated by the practice of programmes, whether programmes are just "assuming" that results are used for improvement processes or if they truly "facilitating" the improvement process (see next chapter).

2.2 Differences in the Focus of Industry-Based and Regulatory Programmes

The IWA model can be used to describe the different focuses of benchmarking programmes in the global water sector on "performance assessment" and "performance improvement". However, this article adds an additional area of interest to the model which has been identified among all programmes compared – the focus on transparency.

In simple terms, regulatory/mandatory and industry-based/voluntary programmes can be distinguished according to these

[3] [5] in a study for the World Bank and also [12] are using such terminology (additionally, advanced statistical methods, described as „performance benchmarking“ and „engineering-model company“ and „customer survey benchmarking are described by these authors and institutions as benchmarking categories).

three focus areas. Industry-based approaches tend to focus on tools for performance improvement through learning and the search for best practices by best practice workshops, by the documenting of action plans or conducting more detailed benchmarking at process or task level [15, 16]. The tools are described in more detail in chapter 3.

Whereas "Benchmarking" in mandatory programmes is often mainly understood as an activity of assessment and publication of performance [17], these programmes do not count with tools to facilitate performance improvement. Even if additional improvement plans are requested by the government, as in the case in the Netherlands, no tools of learning and of exchanging are provided (Table 2). Instead, it is expected that improvement will be incentivised by publishing of the results.

Additionally, regulators are rewarding and penalizing performance, sometimes based on the benchmarking results or through comparison of PI values, e. g. Ofwat, UK. Sophisticated econometrical models that evaluate costs (for tariff-setting) considered to be benchmarking by the British regulator. The results are used for tariff-setting and may incentivise economic improvement. Additionally, Ofwat is using a so-called Service Incentive Mechanism when setting price caps (a comparative index based on number of complaints and customer evaluation). Another example of an incentive based on benchmarking results is exemplified by ERSAR, Portugal. The best performing operators based on the data collected, audited and managed by ERSAR are publically acknowledged and rewarded in a ceremony.

Giving benchmarking activities in regulatory context a clear function and place may be tricky as it is sometimes difficult to distinguish between the benchmarking tools and other tools used by the regulator. Therefore, additional activities for performance assessment, performance improvement or transparency need to be taken into consideration to understand the logic of the respective regulatory programme, such as:

- Different reporting activities (which are not necessarily called benchmarking):
  - Ofwat publishes a comparative performance assessment of utilities on its homepage and asks utilities to do so individually.
  - ERSAR has developed a mobile device to inform citizens.
- ERSAR works on best practice promotion and workshops, although not necessarily in connection with benchmarking.

Similarly, publication activities are not always considered to be part of the benchmarking exercise by the industry-based programmes, they are, nonetheless, often at least connected to most programmes.

Finally, it must be stressed that voluntary and industry-based approaches to "benchmarking" or "performance assessment" might cooperate or "co-exist" in one country. Such is the case in South-Africa, where the voluntary MBI-Initiative partly builds on mandatory data from the regulator, or in the Netherlands, where the mandatory programme is held every three years in addition to annual voluntary benchmarking, and

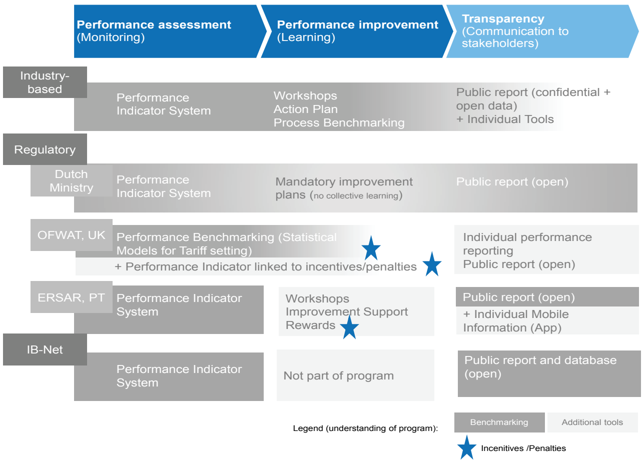


Fig. 2: Scope of benchmarking in chosen different programmes

Fig. 3: App from the Portuguese Regulator (ERSAR) providing key information on each municipality [19]

in the UK, where utilities participate in the voluntary European Benchmarking Co-operation.

2.3 Benchmarking for Learning and Public Information – two different rationales

"Transparency" and the way information is made publically available, is the other main focus (besides performance improvement) where programmes show discrepancies (see Figure 2). Again, a line can be drawn between regulatory programmes, where information is deliberately published to inform sector stakeholders and make the industry "accountable", and industry–based programmes, where public information is rather a consequential and additional goal of programmes. The regulatory programmes (Ofwat, ERSAR, Dutch Ministry) and IBNET openly communicate the results of each utility, hereby not all activities of transparency are necessarily called "benchmarking" (see Figure 2). [7] describes this widely used regulatory practice as "sunshine regulation", where operator's performance is compared, and publicly disclosed and ideally discussed to exert public pressure on those with poor levels of performance:

- Ofwat asks regulated companies to annually report on a set of performance indicators to ensure companies are *"accountable and responsive to their customers' expectations"* [18]. The recommended set of indicators is chosen to *"be a useful tool for customers, regulators, investors and other stakeholders to formulate an understanding of a company's performance"* [18]. The main part of reporting is done by utilities themselves; additionally Ofwat publishes a small set of indicators on its homepage.
- ERSAR has developed a mobile device application to inform customers. It includes information on a set of performance indicators and the relative performance of these indicators in comparison to the sector in Portugal [19] (Figure 3).
- The Dutch mandatory programme lists transparency as one of the main objectives of its benchmarking study: *"The Benchmark focuses on providing openness to all the interested parties, including supervisory directors and shareholders. It is an instrument whereby the drinking water companies account for the way in which they implement their public duties. Transparency and efficiency are improved by publication of the results and the direction exercised by the board of supervisory directors and general meeting of shareholders."* [9].
- The goals of the IBNET database should also be understood in this regard. The objective of IBNET is to *"support access to comparative information that will help to promote best practice… By providing access to comparative information key stakeholders will get the information to do their jobs better."* [20, 21].

This current trend in benchmarking programmes can sometimes lead to a restriction in the concept of benchmarking, so that benchmarking only involves the communication of results. It must be noted, that a management tool focused on learning and improvement differs greatly from a tool geared towards increasing transparency. For example, the recent resolution of the European parliament from September 2015 states that it *"…invites the Commission to set up a benchmarking system… in order to improve the quality of public water supply and sanitation services across the EU, and as a way of empowering citizens"* (European Parliament 2014-2019, 2015). An intensive multi-stakeholder dialogue took place in Europe between the EU Commission and stakeholder of the water sector. The European industry associations urged the European Commission to clarify the goals to be pursued. In the discussion it was emphasised that benchmarking should not be confused with measures to increase transparency and citizen engagement[4)].

It should be mentioned that the effects of transparency on accountability and the so called "power of sunshine" are still being explored. Moreover, transparency concerns the provision of useful and meaningful information and that requires a lot of very specific thinking on the communication mechanism to be used (e. g. sent messages, potential addressees, communication tools, form of presentation, collection of feedback, etc.):

"Simply publishing the benchmarking results does not necessarily equate to more transparency." (Statement of Aqua Publica Europea in Multi-stakeholder dialogue).

4) All documents in the dialogue are published by the European Commission *https://circabc.europa.eu/faces/jsp/extension/wai/navigation/container.jsp*

Specially designed communication tools of tariffs and the background for tariffs from industry-based programmes from Canada and Germany are examples of such additional and focused communication (Figure 4). Information obtained from benchmarking programmes and performance assessment is used, not just by publishing a list of PIs, but by presenting targeted communication.

3 Key Success Factors of Performance Improvement in Industry-based programmes

3.1 Performance Improvement – the Main Challenge

A challenge many benchmarking programmes face, both within and outside the water sector, is to not regard the performance assessment stage as the final stage, but rather to continue to ensure change and improvement inside participating companies is achieved. The following quotes exemplify how benchmarking programmes throughout the world are facing this issue.

- When summarising current trends [3] states: *"Structured formal benchmarking needs to be given more emphasis, particularly involving face to face human interaction in order to learn and share details of best practices that can be implemented through effective and learned change management."*
- Also [22] has seen this trend: *"The focus of benchmarking studies has gradually shifted. In early studies, the focus tended to be on performance measures.... Recent studies have examined how non competitors and industrial outsiders learn how to improve business processes. Comparison of performance measures has developed into learning about best practices."* Even in the mid-90s a survey of 59 organisations came to the result that finding mechanism to "transferring best practices" was given the highest priority by respondents and therefore *"developing a process and mechanisms for transferring best practices is an area of high concern."*
- [14] writes about the finish of the performance assessment phase: *"Sometimes benchmarking exercises end right here, with glossy reports for external communication. However, at this point the benchmarking process is just mid-way and to get real added value out of the exercise, it is essential to go on with the next stage…The performance improvement stage is not just the most essential part of the exercise. It is also the most challenging part of all."*
- A South African manager summarizes that "*benchmarking has not really taken root in our sector in low and middle income countries (despite many attempts to introduce the concept), possibly because the approach is often seen as a tool to expose and embarrass, rather than as a tool to share experi-*

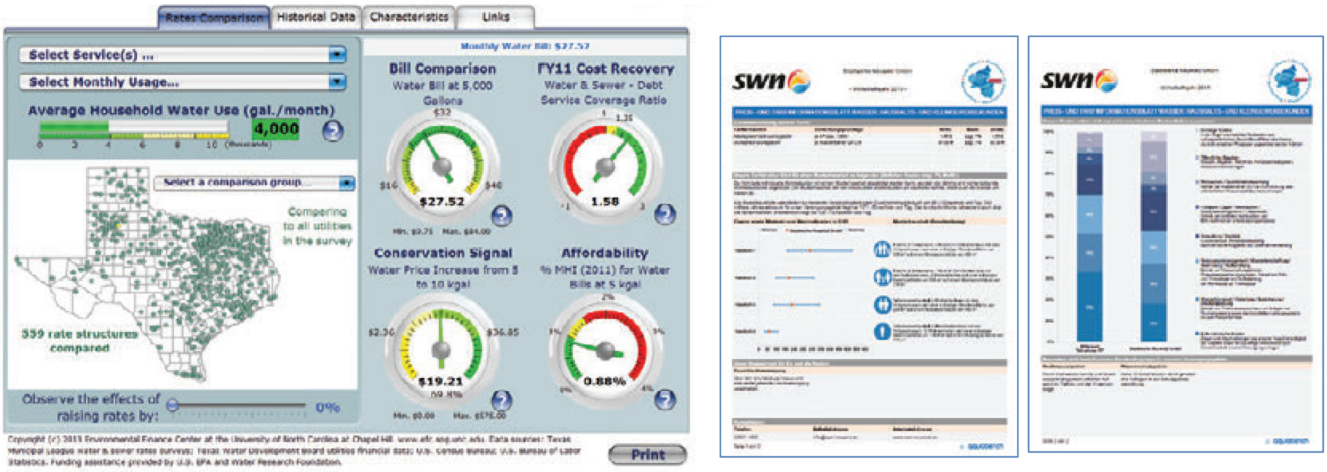


Fig. 4: German and Canadian tools for the communication of tariffs[5)]

[5)] Lombard & Main, 2013; Ministerium für Umwelt, Landwirtschaft, Ernährung, Weinbau und Forsten Rheinland-Pfalz, 2016

ences and learn from each other in a positive and developmental way." [23].

A survey conducted in 2012 of the activities in the German industry shed light on the main success factors for performance improvement in benchmarking [16]. The following success factors should be noted.

3.2 Benchmarking at the Process Level Induces Change More Directly

Benchmarking at the process level generally involves employing focussed assessment tools and systematically searching for best practices – exclusively relevant to a specific detail of the service (function, process, or task). For example, when benchmarking at the process level, the process owner (or manager of the process) is directly involved. The manager is best equipped to assess the effects of improvements and the meaning of performance indicators – especially by working continuously with the benchmarking method. It is safe to say that benchmarking at the process level generates more detailed action plans, closely related to the change of specific performance indicators. Furthermore, the link between operational change and changes in the indicators is possible almost exclusively at this level (Figure 5).

There are different approaches within benchmarking programmes which allow this, such as exemplified below:

- Benchmarking at the process level can be run as an independent, distinct and continuous programme with own distinct assessment model. The aquabench programmes have actually started with such an approach [24, 25]. These programmes have been running for almost 20 years, each having their own circle of participants and their own assessment system. More than fifteen methods have been developed to date, covering almost all parts of the water sector value chain[6)].

[6)] Another example is the programme of WSAA in Australia, where independent benchmarking projects are focusing on asset management or energy efficiency

- In other international programmes benchmarking at the process level is mostly the result or consequence of the work at a corporate level. These projects are often run for a limited time, depending on the need of participants to focus more on given subjects. This is the case for the Canadian programme [26] and the programme of the six Cities group and the South African programme. An own assessment system is not always developed in such an approach. The work at the detailed "process" level and the search for best practices is not always done by separate performance indicators or assessment systems. Exchange of experience, focused analysis of process steps and/or tracking of selected performance indicators of the general assessment system are used as learning tools.

3.3 The Importance of Ownership of Management

Management involvement is essential to ensure improvement:

- *"In the implementation of the results lies the greatest (real) use for the companies involved in benchmarking projects. This phase at the end of the project lies, as a rule, completely in the hands of the companies, however it forms a compelling condition for a benchmarking project."* [6]

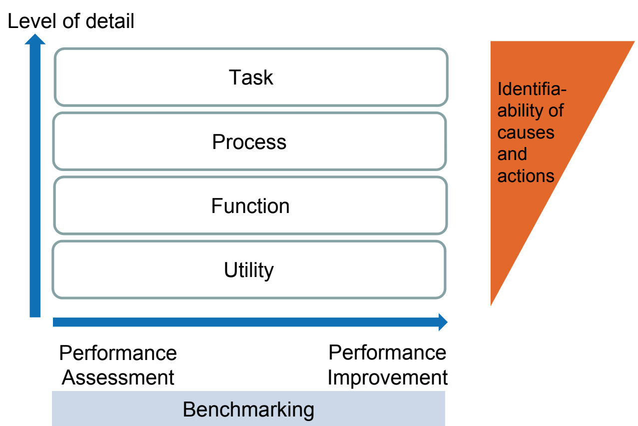


Fig. 5: The importance of the level of detail for identification of causes and actions in a benchmarking process

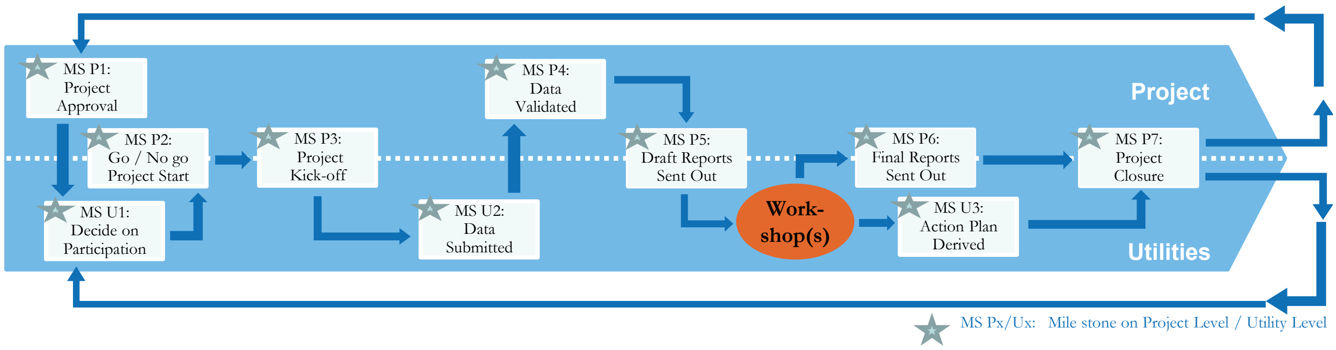


Fig. 6: Central role of workshops in industry based benchmarking programmes [14]

- The IWA Specialist Group on Benchmarking and Performance Assessment come to the same conclusion – without active involvement from companies and their management benchmarking does not lead to success: *"At this point, utility management needs to step in."* [14]

Modifications to operational practices must be in line with corporate strategies. The elaboration of benchmarking results and the integration of these results into operational activities require a high degree of individual decision-power by the companies. The local management should be able to take into account external constraints and internal factors, such as existing resources and priorities (up to and including the companies' readiness to change), and the knowledge must be incorporated in the benchmarking process.

The incorporation of management and greater ownership of management of risk for their companies is also key for the understanding of the new regulatory approach from Ofwat: *"We want a new approach, where companies are responsible for managing their risks ....*" [18], e.g. meaning that utilities are asked to devise own performance reports for the customer and explain to the customer their achievements. This approach results in reduced data collection efforts and much higher responsibility for the utilities.

In summary, the consequences of performance assessment are always to be determined and implemented for each participant individually. This cannot solely take place through an aggregated centralized report and without the involvement of participants.

3.4 Supporting tools and activities

Performance improvement can be supported by tools, the following aspects should be noted for this:

- Workshops are a crucial link between the assessment and improvement phase (Figure 6). [14] describe the goal of such workshops as follows:
  - Getting a common view on results
  - Analysing the reasons for deviations
  - Deriving the keys for good practices
  - Drafting action plans
  - Engaging in networking and Exchange
  - Improve methodology
- Clear documentation of action proposals and best practice solutions is needed. Continuous and regular benchmarking efforts allow tracking of such action proposals. Results and experiences of implemented actions and best practices can be shared within the project.
- In most industry-based approaches, rules on confidentiality of the information received creates, ensures, and protects a learning environment. Such agreements do not exclude agreed measures upon public disclosure activities.

4 International Search for Best Practice by industry-based approaches – Tendencies

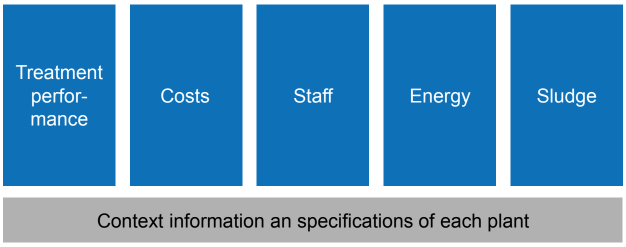
The industry-based approach of benchmarking has started on national level, but soon has transferred also across the borders, more and more projects and co-operations have been developed in recent years:

- The programme of the 6 Cities group in Scandinavia is an example of a programme developed by utilities. It was developed by the utilities from Sweden (Stockholm, Malmö, Gothenburg), Denmark (Copenhagen), Norway (Oslo) and Finland (Helsinki). Today the group is expanding and four more cities have joined from Norway (Bergen, Trondheim) and Denmark (Odense and Aarhus). It has 20 years of history and was one of the first programmes in the sector sharing its experiences in International publications [27].
- European Benchmarking Co-operation (EBC) was founded by Dutch and Scandinavian industry associations in 2006. Its current board include Association of the European Federation of National Associations of Water Services (EurEau) and Danube Water programme (see below). The programme runs annually for Western European countries since 2006. Five regional benchmarking initiatives in Eastern Europe are supported by the programme since 2014. It has high influence on assessment and benchmarking standards in European water sector.
- The Danube Water Programme, a partnership between the World Bank and the International Association of Water Supply Companies in the Danube River Catchment Area, *"...supports policy dialogue and capacity development to achieve strong utilities and sustainable services in the water supply and wastewater sector of the Danube region."* [28]. Actually, regulatory programmes and programmes by industry associations are cooperating in Water Danube Programme. One cornerstone of its strategy is the support of supra-national benchmarking activities in several regional hubs, which are supported by the European Benchmarking Co-operation. In addition to that, the DANUBIS Water Platform is built up, which should *"…develop a regional, public performance indicator system for WSS utilities in the Danube Region, in order to allow for country and utility performance data comparison."* [29].
- The Water Service Association of Australia has developed an Asset Management Customer Value Project (AMCV). The AMCV, and the AMCV framework that underpins it, has been used by almost all large urban water utilities in Australia and over 50 participants worldwide since its inception. The initial project was commenced in 2004 with subsequent benchmarking rounds being held every four years to 2012. Currently a new round is starting.
- aquabench benchmarking methods are used by operators from Austria, Belgium, Poland and Switzerland. Its software is used by benchmarking programme of French public utilities (FNNCCR) and by Arab Countries Water Utility association (ACWUA) for regional benchmarking programmes. More than 10 trainings have been conducted for international experts in Arab countries and East and West Africa. Actually, also regulator in South America have consulted aquabench on advise on benchmarking tools. Currently, aquabench and German operators invite European operators to work with such method on an international level (see info-box).

Benchmarking at the process level "Wastewater Treatment Plants"

Based on 20 years of experiences in Germany, aquabench together with two major German operators (Emschergenossenschaft/Lippeverband and hanseWasser Bremen) invites to an international exchange of operational and technological experiences in WWTPs. With a proven record of success (more than 200 action proposals in three years of benchmarking and more than 270 participants), our methods help to obtain a detailed assessment of own performance and to enable systematic work on improvement opportunities.

Benchmarking at process level of WWTP is focused on important performance areas:



- Treatment performance
- Operational costs
- Staff
- Energy management
- Sludge treatment and disposal

The structured benchmarking approach
- takes into account differing context information and operational characteristics
- follows well known steps of benchmarking according to international and national standards, by German Water Associations (DVGW/DWA), European Benchmarking Co-operation (EBC) and International Water Association (IWA)
- brings in German data and experience from 20 years of benchmarking with more than 270 WTTPs
- works on action proposals for each participating plant

Start: end of 2016

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German Assistance to Support the Development of Integrated Solid Waste Management Solutions

Volker Ludwig (Bonn/Germany)

The development of a circular economy requires the stepwise implementation of advanced solid waste management instruments. Even under less conducive local frame conditions there are several approaches which can be applied in order to proceed on this way. The German solid waste management sector is able to support the stakeholders in these countries in order to develop solutions appropriate to their individual conditions.

Several German organizations will be presented in this article which provide technical guidelines for advanced technologies to be implemented. Some of them have been developed by voluntary contributions from experienced experts sharing their know-how with organizations dealing with international standardization processes. The author gives some clues for such guidelines.

At present, an intensive dialogue is running between German experts on how to set up advanced solid waste management systems in developing, emerging and transition countries that contribute best to climate change mitigation and the development of a circular economy. First outcomes of this cooperation of experts from universities, administrations, business, service providers and development organizations that result from a DWA / ANS-working group shall be presented here. Colleagues facing such challenges might profit from this expertise.

Introduction

Although experts see the necessity to develop the solid waste systems presently applied, many of them have difficulties to take the necessary steps. As a recent poll [1] shows, the Waste Framework Directive of the European Union [2] is known and acknowledged worldwide but the objectives are often seen as not achievable under the local conditions or the waste hierarchy is felt to be not functional. Germany has one of the most improved waste management systems in the world. It fulfills and even partly outperforms the objectives of the Waste Framework Directive. Nevertheless in Germany the discussion continues about the best way to achieve the circular economy in terms of the stepwise improvement of recycling the great variety of wastes including polluted waters.

Various associations [3], universities [4], pressure groups representing public [5] or private companies [6] and even individuals working in the sector take part in these discussions. This interactive exchange of different points of view of stakeholders with various professional background brings the sector continuously forward. The German government and the Federal State's legislative authorities [7] respectively take these contributions and opinions into consideration in an organized consultation process when developing national laws or contributing to the legislation on the European level.

Now, after the European Waste Framework Directive has been set up, each of the five steps of waste hierarchy – prevention, preparing for reuse, recycling, other recovery (e. g. energy recovery) or disposal – is intensely discussed in Europe, especially with regard to the time schedule and the methodology to achieve the goals. Experts and authorities in some countries feel that they could not apply the waste hierarchy in their communities due to the difficult local conditions.

Here, German experts have helped (see European Twinning Program) and can further help to find appropriate local solutions due to their experience concerning regionally differentiated solutions for advanced solid waste management in the last decades in Germany. Foreign stakeholders can profit from the huge know-how German experts have gathered in such locally differentiated discussion processes in the Federal Republic of Germany.

The contribution of German associations and institutions to solid waste management issues is not limited to national or European aspects but also addresses developing, emerging and transition countries how to set up advanced solid waste management systems and how to improve the climate change mitigation and the development of a circular economy. The contributions are manifold by editing publications, providing translated German documents or starting initiatives related to the subject. Various stakeholders from universities, administration, business, service providers and development organisations have started to tackle this task by installing working groups as a forum for the exchange of experiences and for elaborating recommendations, organising conventions, meetings and other actions.

Steps to Modern Waste Management [8]

The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) together with other national stakeholders published a little booklet explaining the necessary steps to implement a modern waste management system. Responsible stakeholders can use it as a guide. The booklet explains the social, economic, organizational and technical framework required to introduce an advanced and sustainable solid waste management system on the long run; it distinguishes five steps of evolution. For each of these steps, all components of a solid waste management system are addressed – like necessary investment into technologies, suitable participation and education models and appropriate financial framework to cover costs. The booklet describes legal, organizational and administrative structures necessary for the regulation of the sector. It has to be underlined that the booklet is not a roadmap to implement circular economy in all countries of the world in a standardized way but it shows how Germany did to achieve the present state of the waste management system. The booklet was published in German and in English language and an electronic version is available from the author. For IFAT 2016 in Munich a new version will be available.

VDI Set of Guidelines

Another source of information are the guidelines and standards published by the VDI Association of German Engineers [9], which is the largest engineering association and the third largest standardization organization in Germany. The VDI Set of Guidelines is ”drawn up by experts from interested circles working in an honorary capacity together with full-time employees from the respective VDI organizational unit in VDI Guideline committees“ [10]. The aim of these guidelines is clearly the transfer of advanced technical know-how to engineers and students. Concerning waste management the guidelines provide technical guidance on all steps of the waste management chain [11]. All guidelines are written in German and in English; so international users can easily profit from.

DWA Advisory Guidelines

DWA [12], the German Association for Water Management, Wastewater and Waste, is publisher of this international special edition of the *KA* journal. Additionally, several DWA advisory guidelines concerning the wastewater and the solid waste sector are a supportive source for decision-makers and experts. The guidelines can be ordered via the website of DWA.

Like other institutions, DWA provides training courses and seminars for the international public, offers vocational training courses and cooperates e. g. with GIZ in various international projects [13].

ReTech: German Recycling Technologies and Waste Management Partnership e. V.

RETech [14] is an association promoting recycling and waste treatment technologies offered by German companies working in this the sector. International partners interested in German technology might contact this initiative directly. The activities are supported by various stakeholders of the German waste management sector including the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). The members of the advisory board of ReTech represent various stakeholders within the sector like universities, ministries, industry, business associations [15] and development organizations. The members of the association are mainly companies providing consultancy or equipment.

In case international experts are intensely involved in the discussion of new ideas and the development of advanced waste management systems they should have a closer look to the following working groups and associations.

Working group “International Solid Waste Management” of DWA/ANS (KEK-5)

The KEK-5 is a committee of experts under the umbrella of the DWA [16] steering committee of circular economy, energy and sewage sludge on the one hand and the ANS [17] (Arbeitskreis zur Nutzung von Sekundärrohstoffen und für Klimaschutz – Working committee for the use of secondary raw materials and climate protection). The committee KEK-5 aims to intensifying the dialogue between experts and responsible persons about their experiences in waste management projects in developing and emerging countries, sharing the lessons from these case studies and generating comments, documents and contributions to the discussion about new or more appropriate ways to develop advanced and integrated solid waste management systems under such conditions. The focus is set on climate change mitigation, as well. Members of the KEK-5 are representatives from BMUB, GIZ, universities and other associations like ReTech, KfW and DGAW. The working group invites guests from other parties as temporary participants depending on the subject. The committee is chaired by Dr. Pfaff-Simoneit from KfW Development Bank [18].

At present, the working group is inter alia discussing the “5 step concept” which forms the governing model for the development of solid waste management systems within German development Cooperation [19]. RETech has adopted the 5 step concept as the guiding model by amending the dimensions policy – society – markets – financing/cost recovery. It was published in the above mentioned BMUB booklet. Dr. Striegel who has broad experiences in national waste management administration and in international waste management projects is working on the further development of the 5 step concept and specification for different waste types on a scientific basis [20]. The idea of the concept is to address the importance of *integrated* solid waste management systems dealing with all aspects of a successful social, economic and environmental sound evolution towards a circular economy. The concept aims to describe all necessary fields of activity – legal, administrative, technical, financial, organizational and social components as well as planning, publicity and training issues. All these aspects shall be described and correlated with each other for each of the 5 steps of maturity of a country’s waste management system and for all types of solid waste. To be successful the system always must focus on economic growth, job generation and prosperity. Results of this activity will be presented soon.

Annual Scientific Conference on Waste Management and Resources Economy

The Scientific Conference on Waste Management and Resources Economy (Wissenschaftskongress „Abfall- und Ressourcenwirtschaft“) [21] is an annual meeting where experts can learn about the outcome of research of universities or scientific institutes in the solid waste sector. Some of the speakers present their master theses or results of their doctoral theses. The conference is organized by DGAW in cooperation with various universities. The idea is to enable the exchange between practitioners from the waste management sector and the scientists concerning meaningful evolutions and progress in solid waste management concepts and technologies. The conference offers abundant space for participants to enter into contact with representatives of universities and scientific institutions like Fraunhofer Institute [22].

Fairs like IFAT, Terratec and meetings on fairs

Experts searching for special machinery or technical solutions might visit the various trade fairs in Germany like the IFAT in Munich (Trade Fair for Water, Sewage, Waste and Raw Materials Management) [23] or the TerraTec in Leipzig (International Trade Fair for Environmental Technologies and Services) [24]. IFAT has gone international and organizes fairs every year in Ankara (Turkey) and Mumbai (India) and every second year in Johannesburg (South Africa) and Shanghai (China). German associations regularly present their activities at these fairs within their own booth, organize events and public discussions. Therefore these fairs are also a good chance to meet and discuss with experts from independent scientific-technical associations or members of these associations. DGAW will organize a meeting at the IFAT 2016 to discuss the international cooperation with its partner associations from the waste management sector worldwide. An important topic will be the initiation of a permanent exchange of point of views concerning the aim of a circular economy.

In order to find suitable trade fairs for your technological demand you might visit the website of the Association of the German Trade Fair Industry [25].

Conclusion

Due to its long lasting and locally diversified evolution of the waste management sector and also due to the highly differentiated and intense international cooperation of the Federal Government, Germany owns a high level of experience, a great variety of resources and a big number of experts who can provide all sort of know-how in order to assist developing and emerging countries in the field of waste management. A great variety of case studies and projects of German International Cooperation show that a circular economy in terms of an integrated and advanced solid waste management system can progressively be implemented even in countries and communities with poor preconditions. Each country might develop its own locally adapted approach, but should not forget that an immense information pool, technical guidelines, experiences technologies and successful strategies are available from the German side. Stakeholders intending to develop the solid waste management systems in their countries are well advised to address German experts, associations, organizations and working groups in order to provide support in developing appropriate approaches and solutions.

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Sustainable Water Management in India

VESBE e. V. (registered association), a private provider of vocational training based in the Cologne region in Germany, was founded 1999 in Aachen and has together with its partners, the Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA) of the Technical University of Aachen and the Fraunhofer Institute of Human Factors and Technology Management (IAT), established a professional training course in the areas "water management" and "wastewater treatment" in India since 2013. The project "Exporting Vocational Training in Urban Water Management to India" (BIBS) is funded by the German Federal Ministry for Education and Research.

BIBS is embedded in Germany's long-term engagement to help India improving its water supply and -quality in a sustainable way. The project focussed on the state of Maharashtra, house to the city of Mumbai, and the second-tier city of Pune in particular.

An important starting point for the region of Pune is the level of training employees in facilities for water treatment and water purification. In addition to a technology gap there are also deficits in the necessary know-how about maintenance and efficient use of equipment. Another problem is the social stigma associated with jobs related to wastewater treatment and water purification, which causes high fluctuation of personnel.

This is the docking point for the BIBS "water management" course. The training course is set up according to the German Dual Education System and provides skills for water treatment and purification facilities in a compact design. In addition the course will provide a German certificate, which will increase the reputation of the employees, often suffering from a low level of recognition for their job. The main target of the training course is the qualification of competent personnel, which can be recruited by operators and corporations in the region immediately.

Analysis of the local situation in India

Right from the project start it was obvious that a simple duplication of the German approach of dual education in professional vocational training was impossible. Therefore the project partners conducted a comprehensive need analysis with the Indian All India Shri Shivaji Memorial Society (AISSMS), Industrial Training Institute in Pune (ITI). For the study, 58 interviews with operators of water treatment and water purification facilities in Pune region were held. The focus lay on the analysis of the local conditions, detailed needs as well as obtaining relevant information for the course design. Besides the interviews with the operators, important multiplier institutions like German technology corporations, the German Water Partnership e.V. or the Indo-German Chamber of Commerce were asked for their experiences. The results showed high potential for the project, as well as big challenges, like different languages and dialects of the employees, generally a low willingness to pay for training and bureaucratic difficulties.

The full study and results were published in autumn 2015 and are available for 39 € in the online shop of the Fraunhofer Institute (*https://shop.iao.fraunhofer.de/details.php?id=650*)or as free download on the official project website (*http://bibspro.com/uploads/media/Modernizing_vocational_education_and_training_in_water_management.pdf*).

Background

As mentioned in the introduction India already possesses water infrastructure like water purification facilities and also modern pipeline systems in some areas. Despite this, qualified personnel who can maintain this infrastructure and is competent to react on errors and accidents, is still hard to find. The results of the BIBS study, (which includes data from 58 local operators and corporations) tell us that 37 % of the technical personnel in treatment plants have not undergone any training at all. As everywhere in India the fluctuation of employees with low education is quite high. The companies accordingly have difficulties to recruit qualified and experienced personnel. More than half of the interviewed operators and corporations, mostly small and medium-sized, confirmed this fact. Most of the interviewed operators and corporations have their roots in the sector of industrial water treatment and water purification. Main focus areas of the interviews were education and advanced training of their employees as well as technical equipment details. Most go for the training approach of internal training on the job. External education providers were only consulted by 9 % of the operators. A decisive problem in training activities is the multi-lingual Indian labour market. Besides English and Hindi, there exist several dialects and other tongues. In Pune e.g., Marathi is quite common. Especially employees with low levels of education mostly only have basic English skills, so for vocational training it is necessary to include regional languages and dialects to reach these employees. Because of the language challenge and practical focus only 30 % of the training content is taught in theory. Theoretical education is mostly provided for employees with higher education levels.

Zaheer Shariff, Scientific Researcher (Institute for Sanitary Engineering, Water Quality and Solid Waste management (ISWA), University of Stuttgart), demonstrating the 3D model for water and wastewater treatment training

As a consequence the normal work life is divided: Practical work is done by the low qualified employees, while the more educated ones work in the management. A mixture of these work environments rarely occurs. Besides these quite specific challenges of the Indian water industry, additional problems like corruption, intransparent bureaucracy, changing responsibilities and employees are impeding a sustainable development in the water sector.

This background was the reason for VESBE e. V. and its partners to implement the BIBS project, so that India will be empowered to use its full potential in the water sector in future. An improved water infrastructure is not only a huge step forward for the Indian population but also for its economy and the environment.

Development of training courses

The BIBS training course of "water management" was set up in close cooperation with ISWA and used the need analysis as a fundament. ISWA has impressive know-how in this area, since it developed comparable training programmes in South Africa or Peru. The main objective was to build a lean, flexible and efficient training course, which includes all necessary contents but also sets focus on integrating modern elements of vocational training. As a consequence the course has a strong profile of visualization techniques and practical components. Two highlights of this approach are the "Environmental Discovery System" developed by FESTO, which makes it possible to teach physical and chemical processes in water treatment, and the 3D-Model developed by Fraunhofer IAT which helps practicing the treatment of emergency error situations in water treatment facilities. The 720 hour course is completed by contents regarding work and health protection. The modules are divided in basic and advanced modules in order to have clients choose the contents according to their specific needs.

The training programme focuses on international and local corporations and operators to train their employees in specific areas of water management. This will help to unroll the full potential of the water infrastructure and to successfully modernize the Indian water industry.

Train-the-Trainer workshop in Germany

One of the main characteristics of the project is the Train-the-Trainer approach: qualified trainers receive expert training and are be able to provide training themselves on a local level once they have successfully completed the course. The first train-the-trainer workshop was held for eight instructors of the AISSMS in Germany in April and May 2015. Besides technical knowledge, didactical elements played an important role. The training took place at ISWA in Stuttgart for most of the time, but the participants also gained practical knowledge, e.g. when they visited a municipal water treatment facility in Hennef, Germany. All participants successfully graduated the programme and received their certificates.

BIBS – the status right now

The BIBS project is now in the last year of funding. The first training course has started on 22nd of February 2016 at AISSMS in Pune. The other project partners provided assistance and helped with didactical questions when necessary during the pilot phase of the course.

Jürgen Lau, CEO of VESBE, attending a panel discussion on the IFAT 2015 in Mumbai (photo: Messe München)

After the first modules were completed there was an evaluation of the training programme to optimize it and to change contents or the didactical set-up where necessary. This evaluation not only included the feedback of the trainers themselves but also the opinion of the participants. As soon as the final evaluation has been implemented the project will be terminated successfully end of May 2016.

Indo-German Competence Academy Pvt. Ltd. founded by VESBE

During the BIBS project, the importance of competent partners in Germany as well as in India and the sustainability focus became obvious success factors. VESBE decided in 2015 to disseminate the project results also after project termination and founded its own training academy in India.

In cooperation with the Takshashila Education Trust, VESBE founded the Indo-German Competence Academy Private Ltd. (IGCA) on the 12th of October 2015. The headquarter in Mumbai and the branch office in Pune, where VESBE will continue to cooperate with the AISSMS, will both offer training courses in the area water management.

Additional programmes are available, among them a six months course for the Pollution Control Plant Operator (Air & Water) or tailored courses for corporate clients who want or train their personnel in specific areas.

Since the quantity aspect plays an important role in India, IGCA will start a franchise approach. The main target will be the training and certification of other training centres, so they can offer the IGCA courses on their own. VESBE will act as a quality control body for the correct implementation of the German training elements and standards.

The future vision for IGCA includes a broad variety of training courses in areas where the Indian economy is in need of skilled personnel. Like with the water management courses, the German education model will be adapted to the specific needs of the Indian industry.

IFAT 2016 in Munich

VESBE will attend the IFAT in Munich 2016 and present information on the BIBS project and IGCA. Together with the German Association for Water Management, Wastewater and Waste (DWA) and other education and research institutions, VESBE can be found in Hall B0. KA

Germany as Host Country During the ExpoAgua 2015 in Peru

Hans-Werner Theisen (Lima/Peru)

From October 21 to 23, 2015, the Peruvian capital city of Lima hosted the ExpoAgua event (www.expoaguaperu.com), which took place on the campus of the Agricultural University La Molina. The event comprised a trade fair and two international conferences – the 10th Inter-American Meeting of Experts on Water and Sanitation for Urban Settlements and the 3rd Technical Conference on Indirect Industrial Wastewater Discharges (ProVMA) – where international experts discussed the latest developments in the supply of drinking water and wastewater management. Germany was invited as host country.

In recent years, South America has experienced significant progress in supplying the population with drinking water. However, wastewater management continues to be a particular challenge. In the coming years, Peru has planned huge investments to improve the wastewater situation decisively. In the past, mainly industrial and commercial wastewater has been discharged in an uncontrolled manner into the sewage system. As a consequence, sewage systems are under considerable strain and treatment plants in densely populated areas are overwhelmed due to the waste load. Since 2013, a new law regulates industrial discharges and, after initial difficulties (such as the lack of accredited laboratories in provincial regions for measuring control parameters), the new standard is now increasingly implemented. Industrial and commercial enterprises must declare their wastewater discharges and apply pretreatment processes if necessary. Otherwise, they are subject to heavy fines and even to the closure of their establishments. In Lima alone, 8,000 of 78,000 commercial users have already been registered. Many of these will have to adjust their processes or pretreat their wastewater in order to comply with the standards. The Ministry of Housing, Construction and Sanitation foresees that the private sector will have to invest around 60 million dollars in the coming years to comply with the present standards. The German development cooperation supports the introduction of the new regulation on indirect wastewater discharges by offering consulting services to the sector's institutions and by building up laboratory capacities.

With the idea to invite Germany as a host country, the organizers pursued the aim of promoting technology transfers between Peru and Germany. Supported by the German Water Partnership (GWP) and the German Chamber of Commerce in Peru (AHK), more than 10 German companies presented their expertise and their products at the trade fair, and the well-attended forums allowed them to discuss possible solutions for the current problems in the Peruvian water sector. The German Federal Government's *develoPPP.de* program already represents some of the participating companies in Peru, and the event provided them an opportunity to collect first hands-on experiences on site. The conferences were also attended by scientists from the universities of Stuttgart and Magdeburg. More than 600 water sector professionals were present at the conferences, and the trade fair was visited by around 1500 experts, including private sector representatives. The event was organized by SEDAPAL – Lima's public utility in charge of water supply and sanitation services for the nine million inhabitants of Metropolitan Lima – and the Center for Water Competence (*Centro de Competencia del Agua* – CCA), in collaboration with the Inter American Sanitary and Environmental Engineering Association (*Asociación Interamericana de Ingeniería Sanitaria y Ambiental* – AIDIS).

Both conferences and the trade fair were attended by some 1500 visitors.

Thanks to a well-organized coordination between the German Embassy, the German Water Partnership (GWP), the German Chamber of Commerce in Peru (AHK), German scientific institutions and the German development cooperation, Germany positioned itself as a powerful host country: its extensive experience and expertise in water and environmental technologies allows Germany to offer Peru solutions for its own challenges (especially in the fields of education, water loss reduction and pretreatment of industrial wastewater).

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Achievement of Technical Sustainable Management in Egypt

Fayez Badr (Rod El Farag/Egypt)

The Technical Safety Management (TSM) is a self-control instrument of the German Technical and Scientific Association for Gas and Water (DVGW) and the German Association for Water, Wastewater and Waste (DWA) for the quality management of water and wastewater companies regarding the terms of technical qualification and organization such as operation and maintenance and OHS. Successful TSM examination ensures that all legal and technical requirements are met. Violation of organizational obligations, deficits in view of technique, organization and personnel will be uncovered, reviewed and removed.

From 2009 on the German TSM approach has been adopted, modified and customized under the strategic direction of the Holding Company for Water and Wastewater (HCWW) in order to suit the specific requirements of the Egyptian water supply and wastewater sector. The HCWW is the official Egyptian governmental body with responsibility for 25 affiliated water and wastewater companies throughout Egypt, and is being supported by the German Development Cooperation through the GIZ Water and Wastewater Management Programme (WW-MP). Since 2010, an national inspection body has been installed in HCWW and quite a number of plants were successfully certified under the "Technical Sustainable Management programme TSM Egypt" in accordance with national standards and requirements.

Over the past seven years, TSM Egypt has achieved a lot of success. For example, the total number of TSM Egypt certified water and wastewater facilities reached 60 in 18 Affiliated Companies out of 25. An analysis of the economic impact of the certified facilities has shown the following results:

- Decrease of production costs per cubic meter of water from between 5% to 20%
- Increased lifetime of the facilities' assets due to the application of maintenance management systems.
- The most remarkable impact of TSM Egypt was changing the operator's culture towards personal safety considerations and securing the work environment.

Three Egyptian teams in the professional skill competition at IFAT 2014 in Munich/Germany

Startup of the TSM Arab programme

Safety first in a confined space

For greater sustainability of the TSM Egypt program, seven new inspectors were trained and certified by the TSM Egypt Department in the HCWW, to meet the increased number of the certification applications. In addition, the lessons learned from the TSM Egypt application are shared within the framework of so-called neighborhood days as an initiative that brings together interested Water and Wastewater Plant managers to share experience and learn from each other.

At the international level, GIZ supported the HCWW to attend professional skills competitions at IFAT 2014 with three teams that achieved a good ranking among 14 German and international teams present.

In addition, due to the success of the programme at the local level, BMZ/GIZ financed the transfer of the TSM Egypt concept to a similar programme for the Arab Countries Water Utilities Association (ACWUA).

Now the first version of TSM Arab requirements for water and wastewater facilities is issued and qualified TSM Arab inspectors are certified. This resulted in certification of two pilot facilities in Tunisia and Jordan.

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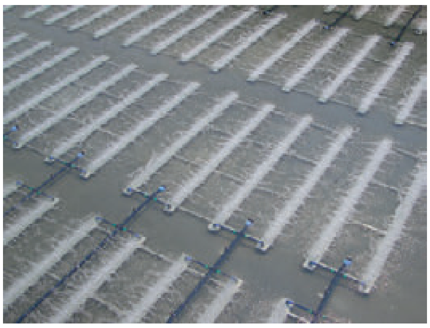
Aquaconsults's fine bubble strip diffusers using a polyurethane membrane are operating in approximately 2000 municipal and industrial wastewater treatment plants worldwide. These diffusers distinguish themselves with high oxygen efficiency of introduced air and a long lifetime.

At IFAT 2016 Aquaconsult presents a consequent further development of their perforation technique, which allows varying form and size of pores to have a direct impact on the pressure drops of the membranes. In combination with online pressure drop measurement during perforation process and instant feedback to the machine it is guaranteed that every single membrane has the same resistance to the airflow. Advantage for operators: Characteristics of membrane can be adjusted exactly to the needs and relevant requirements on-site. This significantly increases cost effectiveness of aeration.



The most efficient oxygenation takes place with very fine bubbles and at low air flow of the diffusers. To provide an equal distribution of air at these circumstances – which is necessary for high efficiency and circulation – Aerostrip diffusers have a pressure drop of about 50 hPa (mbar). That led to oxygen efficiency values of 30g/Nm³/m at field tests.

With the recently developed “Phoenix-Membrane” it is possible to halve pressure drop whilst increasing air flow per diffuser. Long-life polyurethane membrane together with low pressure drop is an economic and unique combination in aeration technique so far.

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Sustainable Solutions for Full Nutrient Removal at the Blue Plains wwtp in Washington, D. C.

The Blue Plains Advanced Wastewater Treatment Plant provides treatment services to more than two million Washington metro area customers. It has the capacity to treat 370 million gallons of wastewater a day and is, according to its operator, DC Water, the largest plant of its kind in the world. The treated water is discharged to the Potomac estuary and there the plant is required to meet some of the most stringent National Pollutant Discharge Elimination System Standards (NPDES) in the United States.

One of the crucial parameters in the effluent is nitrogen. Nitrogen is a primary nutrient for the growth and survival of plants. If the nitrogen concentration in a water body exceeds a certain concentration, it induces explosive growth of

One of 90 Hyperclassic®-Mixer/Aerators in the Back River wastewater treatment plant in Baltimore, MD, USA (photo: HCMA)

plants and algae. When such organisms die, the decomposition process of the biomass in the river causes a rapid depletion of oxygen in the water body. Under a certain concentration of oxygen the aerobic decomposition of the biomass is no longer possible and anaerobic microorganisms start to produce toxic substances e. g. ammonia or methane. This causes decimation in fish and plant population, with the result, that the water body will start emitting bad odors. This very much undesired phenomenon is called eutrophication.

To prevent this scenario, DC Water recently implemented a comprehensive upgrade program for its biological treatment step to enhance treatment capacity and to reduce energy consumption. Therefore, a total of 112 specially-designed, energy-efficient Hyperboloid-Mixers were delivered from the German nutrient removal specialist Invent Umwelt- und Verfahrenstechnik AG. Prior to the selection, DC Water ran extensive tests against standard mixing equipment available locally and internationally and found that Invent's Hyperboloid-Technology could provide better mixing at 50 % less energy consumption. The Invent Hyperboloid Mixing System was developed especially for the suspension and homogenization of biologically active sludge in anaerobic and anoxic basins of biological wastewater treatment plants. The basic design is based on fundamental fluid mechanical considerations, which led to a superior mixing system.

One of 112 Hyperclassic®-Mixers in the Blue Plains wastewater treatment plant in Washington, D. C., USA (photo: DC Wasa Photo)

Currently, the Blue Plains treatment plant is implementing the world's largest reactor for nutrient removal from wastewater coming from the huge sludge digesters the plant runs to produce biogas. These waste streams are extremely high in nitrogen and require special treatment and a deammonification process before they can be discharged into the normal treatment process.

Essential for the Deamonnification Process are the anammox bacteria which were discovered in the 1990s. Anammox bacteria work synergistically with ammonia oxidizing bacteria to oxidize ammonia without organic carbon, producing nitrogen gas. This process requires significantly less oxygen to remove nitrogen, and less energy is needed for aeration. Crucial for the successful large-scale application of the Deammonification Process is excellent mixing at low shear rates in order not to destroy the sensitive granular anammox sludge flocs, and an aeration system with quick response times in order to control the biological process reliably. For this very demanding task the Invent Hyperboloid Mixing and Aeration System was the first choice for the DC Water Side-Stream Treatment Project at the Blue Plains wastewater treatment plant. The Invent Hyperboloid Mixing and Aeration system is uniquely suited for this advanced process which could save wastewater utilities hundreds of million of dollars in aeration and external carbon costs in the treatment cycle.

Invent offers a complete range of fluid-mechanically optimized products and systems for the biological treatment of wastewater. Next to wastewater treatment, they also deliver mixing systems with special features required in drinking water processing. The most recent project in the US of this kind is the Carlsbad, CA, seawater desalination project for which Invent delivered all flocculation mixers.

www.invent-uv.de

Tricanter® for Three-Phase Separation

Flottweg has presented the new Tricanter® Z3E at IFAT 2016. This rounds up Flottweg's product line, offering an attractive centrifuge concept for smaller industrial plants as well. Despite its smaller size, this modular machine has all the features and customization options the "big dogs" do. The Z3E is flexible, maintenance-friendly, and powerful. Another special feature is the "super deep" pond.

Top flexibility and quality are the watchwords for the Tricanter® Z3E. Depending on the application, either a normal or a super deep pond can be selected. With a super deep pond, the Z3E is even better at processing sludges and pastes. But with the normal pond, it is no "dog" either. Its strengths shine in the processing of grainy sediments, with its filtration characteristics.

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- use of high-quality bearings
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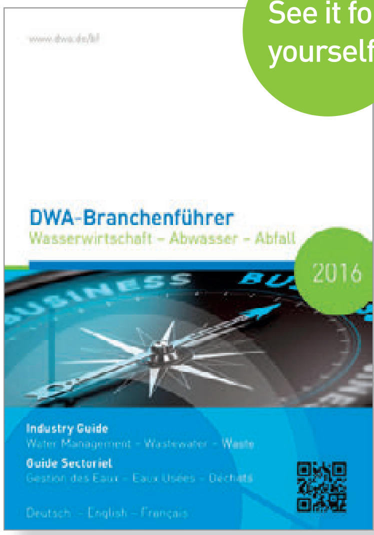

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