International Special Edition 2014/2015

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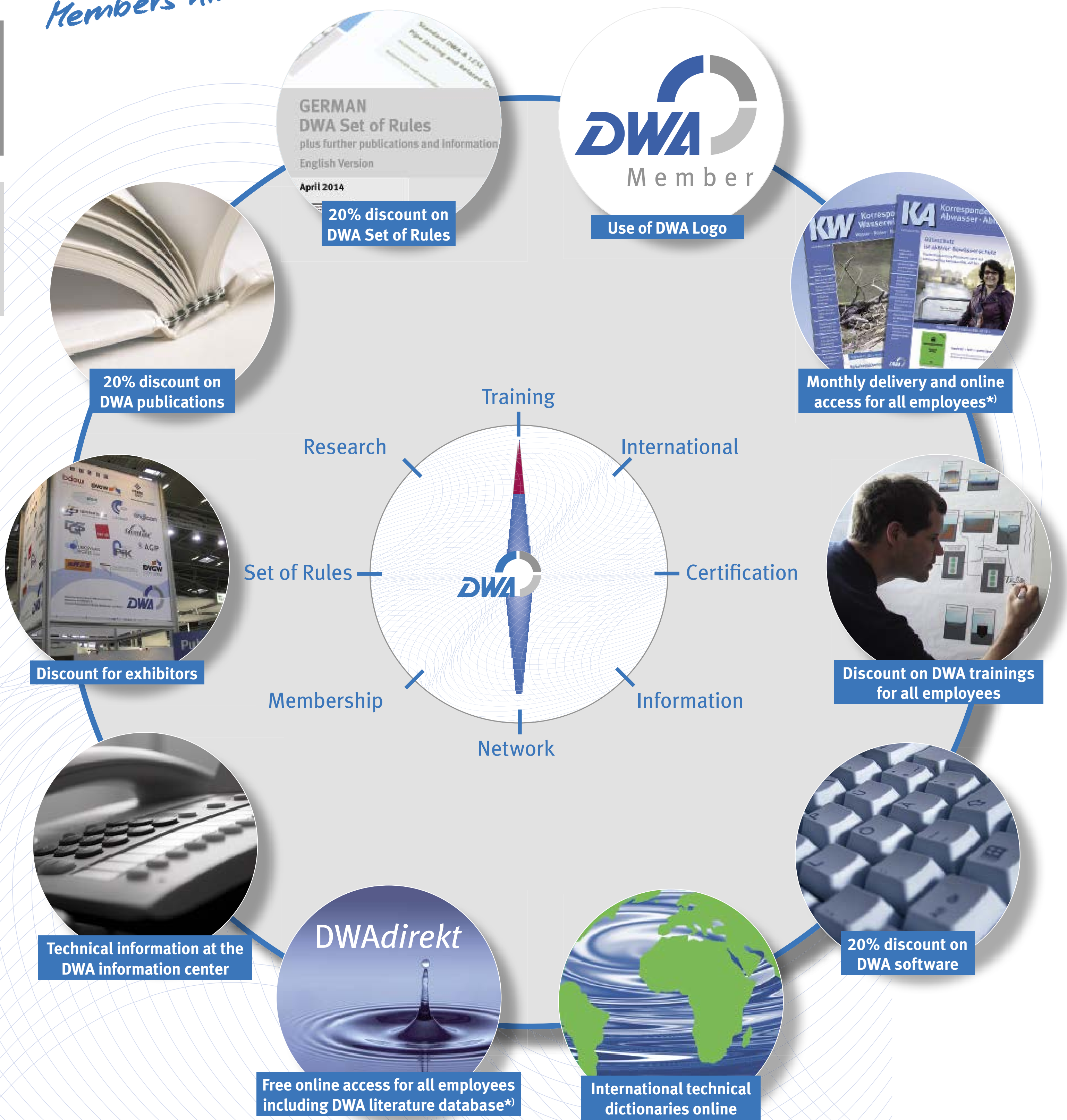

*) Please note that the monthly paper KA/KW and the service DWA*direkt* are in German

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Water – an International Issue

Water is a truly international 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 sparsely populated, markedly industrial regions and distinctly agricultural areas. But the central challenge is to provide a reliable water supply and sanitation and to eliminate residual materials and waste safely anywhere. Countries and continents of the earth are more or less interconnected via the global water cycle, albeit on a small scale, the idea could arise that one is self-sufficient from the rest of the world. Another important task of water management is to ensure that not too much is in the same place. Unfortunately, floods occur again and again. Often it is not the wealthiest countries, who are struggling with floods, but time after time extreme events occur also in countries such as the USA, Germany, France, Spain, United Kingdom. On the other hand, droughts can also be disastrous – not only in Africa or Asia, but also in Europe or the USA.

In addition to the above-mentioned, the water industry always faces new challenges. The demographic development in some industrialized countries has implications for the water industry: Fewer people use less water, the infrastructure is becoming too big, but cannot simply be shrinked, 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. Climate change affects the water cycle – it is to be assumed that it is accelerated by higher average temperatures, that storm rainfalls increase in intensity and frequency and that their seasonal distribution varies.

If the world population continues to grow as predicted, the environmental issue is likely to increase in importance, especially in countries where environmental protection 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. What is no longer needed by one party can be a useful starting material for the other. In this context, the slogan "Urban Mining" has become well established. 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 are already existing. Especially in Germany, environmental technology and water management are well developed. Technology transfer is the magic word. Here, the water management associations like the German Association for Water, Wastewater and Waste (DWA) can be focal points. In these organizations, the professionals and thus the expertise is organized. Specifically, since 2003, the DWA is more internationally active than in the past. For many years, the DWA has been working in international standardization bodies. Standardization on an international level is useful for operators as well as for suppliers of water 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, for example, since 2001 it conducts Young Water Professionals' programs in Germany. Here, more than 600 young professionals have already participated.

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 (Hannover Fair) and many other large and

small special events more, like Biotechnica or Filtech, just to name a few, which are related to water.

A small section of the German water sector and the international activity of the DWA is highlighted in this journal. There are articles on sewage systems and rain water treatment in Germany, the performance of municipal wastewater treatment plants in Germany, a review "from wastewater disposal to recycling and resources management", a survey of international activities of DWA, on Technical Sustainable Management in water and wastewater treatment plants in Egypt and an application report illustrating the upgrading of a sewage treatment plant.

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)

		Title	Euro
☐ DWA- M 114E 	*New!*	**Advisory Guideline** **Energy from Wastewater – Thermal and Potential Energy** June 2009, 48 pages, DIN A4, ISBN 978-3-944328-27 Using wastewater heat we could – in terms of availability – heat 10 % of all the buildings in Germany. Due to rising energy prices on the one hand, and the technological progress of heat pumps and heat exchangers on the other, the use of wastewater heat is becoming increasingly attractive from an economic point of view.	42,00 *)
☐ DWA- M 144-3E 	*New!*	**Advisory Guideline** **Supplementary Technical Contract Conditions (ZTV) for the Rehabilitation of Drainage Systems Outside of Buildings – Part 3: Renovation with Hose Liner Process (locally cured hose liner) for Sewers** November 2012, 43 pages, DIN A4, ISBN 978-3-944328-10-2 This Advisory Guideline supplies supplementary harmonised, standardised technical contract conditions (ZTV) and creates clear benefits both for the grid operator, as well as for the designers and rehabilitation companies. Publication available in Chinese, Czech, English, French, Italian, Polish, Russian and Spanish	78,00 *)
☐ DWA- A 199-1E 	*New!*	**Standard** **Service and Operating Instructions for the Personnel of Wastewater Systems –** **Part 1: Service Instructions for the Personnel of Wastewater Systems** November 2011, 31 pages, DIN A4, ISBN 978-3-944328-47-8 This Standard contains minimum requirements for the contents of service instructions for the personnel of wastewater facilities, which are binding for all operators, irrespective of the type of organization or business. It is intended as a template and guideline to assist operators of wastewater facilities in devising their own service instruction. A sample text has been added as an aid in the appendix.	35,00 *)
☐ DWA- M 507-1E 	*New!*	**Advisory Guideline** **Levees Built Along Watercourses –** **Part 1: Planning, Construction and Operation** December 2011, 109 pages, DIN A4, ISBN 978-3-942964-53-1 The experience gained from recent large flood events in Germany underscored the scale of the required refurbishment and new construction of levees. By providing concrete information and design approaches as well as verification concepts, the guideline is meant to help building contractors and specialists with the design, construction and maintenance of flood mitigation works, allowing them to properly define the requirements that are to be met by structural flood protection measures.	76,00 *)

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		Title	Euro
☐ Technical Pocketbook 	**New!**	**DWA Technical Pocketbook German Water Technology – Operation and Maintenance of Drain and Sewer Systems – 2014** March 2014, 359 pages, DIN A5, ISBN 978-3-944328-41-6 This pocketbook is a selection of Standards and Advisory Guidelines for the Operation and Maintenance of Drain and Sewer Systems and is written for engineers, technical decision makers, consultants and all companies operating in the field of drainage systems. It is not rocket science, it is a guideline for implementation.	59,00 *)
☐ CD-ROM	**New!**	**Special Offer IFAT 2014 – German DWA Set of Rules at update-price – Get the basic version FREE!** **) English translations of significant DWA Rules and Standards 58 DWA-Standards/Advisory Guidelines, 5 DWA-Topics and various brochures at PDF format (single user), Edition: April 2014	~~690,00~~ *) 90,00 **)
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Under the focus of statistics: Sewerage and storm water treatment facilities in Germany*)

Hansjörg Brombach (Bad Mergentheim, Germany)

Based on the latest data of the German Federal Statistical Office for 2010, graphs were drawn up to illustrate the status of the public sewer system, of storm water treatment and retention facilities in the sewer network and the number of waste water treatment plants in Germany. For all Federal States, parameters like connection rate to the public sewerage system, sewer lengths per head, geographical distribution of combined and separate sewerage systems, the number of storm water tanks and their volume, the number of waste water treatment plants and the average inflow/infiltration rates as well as the development of the number of facilities since 1975 are shown.

Key words: drainage systems, sewerage, urban drainage, connection rate, sewer, length, storm tank, combined and separate sewerage system, wastewater treatment plant, inflow/infiltration rates, statistics, Federal State, Germany

1 Introduction

Six precursors [1–6] to this paper, with similar title and contents, have appeared earlier in this periodical. In connection with the series of reports, whose history now goes back for more than 34 years, the status and development of sewage systems and storm water treatment will be described and commented on the basis of the latest official data from the Federal Statistical Office released in 2010. An analogy to the previous publications has been deliberately preserved. A more extensive presentation of the astonishing and rapid development of rainwater treatment over the last 42 years may be found in [5].

Only the "public" wastewater drainage under municipal management, in the form of the sewer network, rainwater treatment plants, stormwater overflows and wastewater treatment plants will be considered below. By definition this does not include private domestic connections, private installations for retaining, reusing and infiltration of rainwater, nor does it include industrial drainage plant or industrial wastewater treatment plant.

The statistical assignment of rainwater treatment plants at state and federal roads and autobahns is not clear.

2 The latest DESTATIS database from 2010

The German Federal Statistical Office (DESTATIS) collects data on water supply and wastewater disposal in a three-year cycle. The last-but-one census was taken in 2007. The latest, and thereby complete, wastewater data from the Federal Statistical Office [7–9] from the last census, taken in 2010, has now been available since 7 October 2013.

All the primary data in Table 1, in columns 1 to 7, 10 to 17, and 19 to 21, have been taken over unchanged from the DESTATIS publications [7–9]. The author has derived the secondary data in columns 8, 9, 16, 18 and 22 from them. As a result of rounding the figures for various states up and down, there may be slight variations in the last figure of the totals of the "Germany" line.

Figures 2 to 7, shown below, are not contained in the report from the Federal Statistical Office, and have been prepared by the author, on his own responsibility and to the best of his knowledge and belief, from the figures given in Table 1.

3 Situation reports for the federal states

In parallel with the Federal Statistical Office, the states publish what are known as "Situation reports regarding the drainage of municipal wastewater and the disposal of urban drainage systems sludge" every two years. These situation reports have been required by European Council Directive 91/271/EEC [10] since 1991, in order to keep the public informed about the status of urban drainage systems. Preparing the reports in parallel cycles of two and three years means, that a common census only takes place every six years. Does that make sense?

The data from DESTATIS and of the state situation reports are structured very differently. The situation reports from the federal states are, again, very different from one another. The

*) The following paper is the English translation of a publication in German from December 2013, see [19]

author has compared a few situation reports for the year 2010, which was the last time the marching rhythm of the states and the federal waltz step fell together, with the DESTATIS data. In the case of the situation report from the Rhineland-Palatinate [11], the state and the DESTATIS data are in perfect agreement. There are glaring differences in the situation report from the state of Hessen [12]: why?

There is an urgent need for action in the management of the water statistics! Marching and waltzing rhythms do not work well together. The situation reports from the federal states should be harmonised with those from DESTATIS, and the two should be aligned.

4 Representative population census 2011 and statistical consequences

Unfortunately it is only since the middle of 2013 that we have known that Germany has significantly fewer inhabitants than had previously been assumed. The representative population census, with a key date of 9 May 2011 – which again is only an extrapolation with the potential for errors – found only 80.219 million instead of the previously assumed 81.729 million inhabitants [13]. The official population figure for the Federal Republic of Germany had to be lowered by -1.509 million, or -1.8%. Berlin has 5.2% fewer inhabitants than had previously been assumed.

In relation to Germany's total area of 356,954 km², these 80.219 million inhabitants represent a population density of 225 inhabitants per km². In comparison with the 2007 census, we have lost five inhabitants per km², four of them as a result of the "population census". We remain, nevertheless, a very densely populated country, and the treatment of wastewater will continue to require careful attention in the future.

The overestimate in the population figure has unfortunately thrown a large number of statistics into confusion, including the statistics for wastewater. If, for example, we were to divide the number of inhabitants connected to the public sewage system according to the 2010 census by the number of inhabitants known for 2013, we would find that seven federal states would have reached a proportion of more than 100% of people connected to public sewage systems – nonsense, of course! In the next census from the Federal Statistical Office in 2013, the specific figures related to inhabitants, such as for example the drain length or the reservoir volume per head, will take a jump upwards. Not because construction has gone on apace – but because the installed equipment is divided between fewer people.

In order to be able to provide a consistent overview of the state of the sewage system and rainwater treatment in spite of the disturbed data basis, the author is staying with the official DESTATIS population figures for 2010 in this article.

5 Inhabitants and rate of connection to the public sewerage system

The figures in columns 1 and 2 of Table 1 been obtained from DESTATIS [7]. Figure 1 was prepared using these figures. The mean connection rate of the population of the Federal Republic to the public sewage system in 2010 was 96.6%, and has increased by 0.5% since the last census in 2007. In spite of the considerable growth since reunification in 1990, the lighter colour of the new federal states still stands out in Figure 1. It is, however, certain that the differences will continue to even out in future.

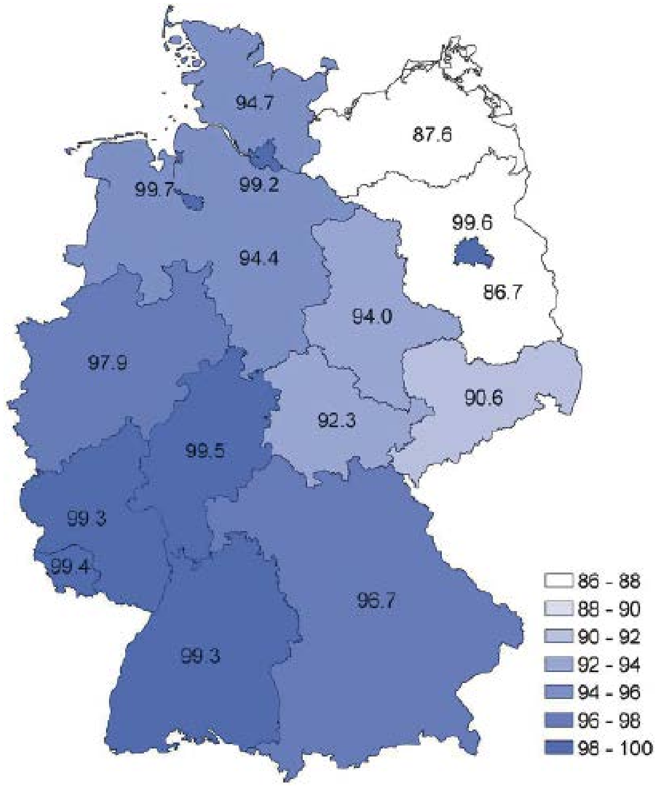

Fig. 1: Rate of inhabitants connected to the public sewerage system in percent, mean annual value 2010

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

6 Rate of connection to public wastewater treatment plants

In the middle of 2010, 9632 wastewater treatment plants were operating in Germany; see column 21 in Table 1, with the figures from [9]. The wastewater from 95.5% of all inhabitants is purified in central, public wastewater treatment plants. The difference of -1.1% from the rate of connection to the sewage system is so small that a map showing the rate of connection to wastewater treatment plants has not been given – it would be more or less identical to Figure 1.

On an international level, the rate of connection in Germany to wastewater treatment plants with second and third purification stages is in fourth position, behind the Netherlands, Great Britain and Switzerland [14]. The performance comparison in [15] provides more details on the purification performance of the wastewater treatment plants in 2010.

In 2010, a federal average of 8487 inhabitants was connected to each wastewater treatment plant. Small to medium-sized plants clearly dominate in Germany. For example, the average wastewater treatment plant in Mecklenburg-Vorpommern had to serve only 2801 inhabitants. In Berlin, according to DESTATIS [7], there was only one single wastewater treatment plant for 3.4 million inhabitants. In reality, the city of Berlin has six wastewater treatment plants, although five of them are located in Brandenburg. This is a good example of the difficulty of maintaining water statistics over the whole republic.

7 Length of the public sewer network

The length of the public sewers (without private house connections) is reported from [9] in columns 4 to 7 of Table 1. In total, at the end of 2010, there were 561,581 km of public drains for combined, sanitary and storm sewers. Since 2007, therefore, the length of German drains has grown by 3.9%, i.e. an annual growth of 1.3%. Between 1998 and 2004, the growth was 2.6% per year. The rate of growth has thus dropped to a half. That would appear plausible.

If the total length of all the public drains in column 7 is divided by the number of inhabitants in column 2, we obtain the mean sewer length per inhabitant; see column 8. The federal average is 6.87 m of public sewer per citizen. Since 2007, an average of 30 cm of municipal sewer has been added for each federal citizen, which is 10 cm of sewer per year. Over the period from 1998 until 2004, the figure was 13 cm of additional sewer per capita and per year. The falling rate of growth is also plausible in the light of the trend in the connection rate.

Figure 2 shows a comparison of the average length of sewer for each inhabitant of all the federal states. It is easy to see that the city states manage with relatively short drains. In 2010, Berlin, with its 3.11 m per head, took the record for the "shortest sewers of 2007" away from Hamburg (3.23 m) again. This is the infrastructure advantage of a megapolis. Lower Saxony, with a very high proportion of rural areas and with 93.2% separate sewer systems, has the longest sewers per head in the republic.

The new federal states have clearly mastered the need to catch up with the development of the sewage system. Figure 2 no longer shows a glaring difference from the old federal states.

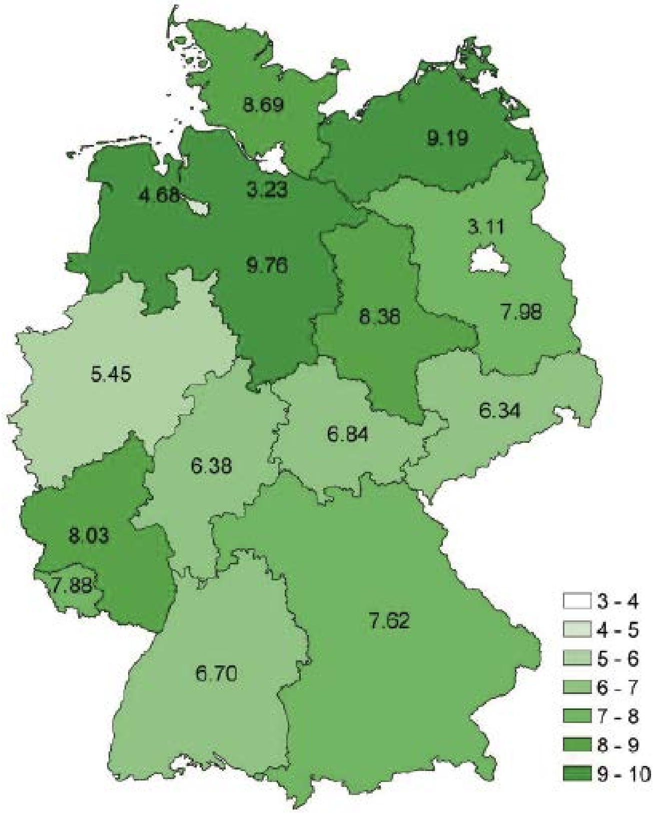

Fig. 2: Length of public sewers per inhabitant in metres at the end of 2010

8 Distribution of separate and combined sewer systems

There are no direct figures in [9] regarding the distribution of inhabitants between separate and combined systems. It is alternatively possible, however, as was also done in earlier reports, to draw conclusions as to the proportion of the population con-

Statistical magnitude CSys: combined system SSys: separate system	Inhabitants on 30/06/2010	Proportion of inhabitants connected to the public sewage system	Length of combined sewers, CSys	Length of sanitary sewers, SSys	Length of storm sewers, SSys	Total length of sewers, CSys+SSys	Length of sewer per inhabitant, CSys+SSys	Proportion of combined sewer systems	Stormwater tanks with overflow (STO) and sewers with in-line storage capacity and overflow (SSCO), number, CSys	Stormwater tanks with overflow (STO) and sewers with in-line storage capacity and overflow (SSCO), volume, CSys	Stormwater retention facilities (SRF), number, CSys+SSys	Stormwater retention facilities (SRF), volume, CSys+SSys	Stormwater sedimentation tanks (SST), number, SSys	Stormwater sedimentation tanks (SST), volume, SSys	Total of all stormwater tanks without SO, number, CSys+SSys	Total of the volumes of all stormwater tanks, CSys+SSys	Storage volume per inhabitant, CSys+SSys	Combined Stormwater overflows (CSO) without calculable storage volume, number, CSys	Sewage systems/receiving waters cross-connections, number	Public wastewater treatment plants (MWWTP), number, CSys+SSys	Mean infiltration/inflow rate wastewater treatment plant 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
Dimension	1000 E	%	km	km	km	km	m/ inh.	%	n	1000 m^3	n	1000 m^3	n	1000 m^3	n	1000 m^3	m^3/ inh.	n	n	n	%
Germany	**81 751**	**96,6**	**241 013**	**199 631**	**120 937**	**561 581**	**6,87**	**54,7**	**23 880**	**14 978**	**20 481**	**36 211**	**3317**	**2691**	**47 678**	**53 880**	**0,659**	**21 099**	**68 777**	**9632**	**45,9**
Baden-Württemberg	10 750	99,3	49 782	11 827	10 406	72 015	6,70	80,8	6900	3814	647	1365	327	149	7874	5327	0,496	3842	11 716	1023	82,4
Bavaria	12 519	96,7	54 330	28 273	12 758	95 361	7,62	65,8	6369	3189	3849	3820	631	511	10 849	7520	0,601	3961	14 810	2539	34,4
Berlin	3444	99,6	1958	5464	3304	10 726	3,11	26,4	21	61	101	700	18	48	140	810	0,235	450	590	1	–
Brandenburg	2508	86,7	619	15 316	4091	20 025	7,98	3,9	54	60	478	702	196	63	728	825	0,329	299	1027	249	5,2
Bremen	660	99,7	803	1172	1110	3086	4,68	40,7	6	80	13	54	57	26	76	159	0,241	22	98	4	11,7
Hamburg	1779	99,2	1258	2790	1695	5743	3,23	31,1	12	99	9	48	31	91	52	239	0,134	149	201	1	36,6
Hessen	6064	99,5	29 122	4390	5163	38 675	6,38	86,9	2714	1810	1038	1226	50	68	3802	3104	0,512	3146	6948	701	91,2
Mecklenburg-Vorpommern	1647	87,6	624	10 705	3814	15 144	9,19	5,5	103	118	542	1127	205	165	850	1410	0,856	391	1241	588	14,3
Lower Saxony	7932	94,4	3339	45 693	28 385	77 416	9,76	6,8	206	345	4263	10 447	89	106	4558	10 898	1,374	562	5120	634	26,4
North-Rhine-Westphalia	17 851	97,9	46 010	28 159	23 082	97 251	5,45	62,0	2834	3192	4321	9072	1022	703	8177	12 967	0,726	1753	9930	650	47,7
Rhineland Palatinate	4007	99,3	21 845	5828	4512	32 185	8,03	78,9	2537	1086	1590	2156	52	33	4179	3275	0,817	2521	6700	705	49,2
Saarland	1020	99,4	6586	562	892	8039	7,88	92,1	628	295	117	137	16	46	761	478	0,469	1452	2213	133	76,7
Saxony	4154	90,6	9954	11 042	5337	26 333	6,34	47,4	607	321	868	1406	143	140	1618	1866	0,449	1434	3052	743	77,7
Saxony-Anhalt	2345	94,0	3443	12 111	4090	19 644	8,38	22,1	229	134	536	656	23	23	788	813	0,347	338	1126	254	30,4
Schleswig-Holstein	2831	94,7	1619	13 103	9881	24 603	8,69	11,0	77	76	1561	2720	423	498	2061	3294	1,164	219	2280	808	11,5
Thuringia	2241	92,3	9721	3196	2419	15 337	6,84	75,3	583	298	548	576	34	21	1165	895	0,399	560	1725	599	46,5

Comment: “–”: no data available

Table 1: Statistical figures for public, municipal sewage system, based on the data collected by the Federal Statistical Office in 2010

nected in each case from the ratio of the lengths of the combined and sanitary sewers, as follows:

CS — combined sewers from column 4 in km
SS — sanitary sewers from column 5 in km
PCS — proportion of population connected to combined sewer systems from column 9 in %
PSS — proportion of the population connected to separate sewer systems (without column) in %
PCS — = [CS/(CS+SS)] X 100; PSS = 100 – PCS

It is assumed here that in larger networks, regardless of the drainage system (separated or combined system), the same number of inhabitants are on average connected per meter of combined or sanitary sewer. The length of the storm sewers is not relevant to this calculation, since the storm sewers must be laid in addition to the sanitary sewers – or the storm sewer is simply not present, or the rainwater flows into a ditch or pond without being recorded in the statistics.

The author is aware that the assumptions made above assign too high a proportion of connected inhabitants to the separate system. Separate drainage dominates in rural areas, such as can be seen in Figure 2 for Lower Saxony, Mecklenburg-Vorpommern and Schleswig-Holstein, and in the newer suburbs and development areas of the cities. The population density is lower there, and the drains are longer per inhabitant. Unfortunately the riddle of how many inhabitants are in fact connected to which drainage system remains unsolved until now.

Even if we were to make a count: what would be the category to which someone would belong who lives in a newly developed area with modern, modified separate drainage, but whose wastewater runs, after a few hundred metres, into the city centre with its 100% of combined sewer systems (due to its history). The PCS formula has been retained in this article, both because of this dilemma, but also in order to preserve the analogy with the earlier publications.

Figure 3 has been deliberately prepared, as the only diagram in this article based on atlas maps with a two-colour palette, in order to emphasise the 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 brown colour.

If we compare Figure 3 with the status since the first analysis [3], it is noticeable that, without exception, separate sewer systems have gained ground in every federal state. In 1989/90, the federal average was 71.2% combined sewer systems. At the last census in 2010, the proportion of inhabitants connected to combined sewer systems was only 54.7%.

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 sewer equator”. The author estimates, as shown in Figure 3, that since 1992 this line has, on average, moved about 5 km further south per year. In fact the equator now ought to tilt from the north-west of 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, putting Dortmund and Göttingen now on the combined sewer equator.

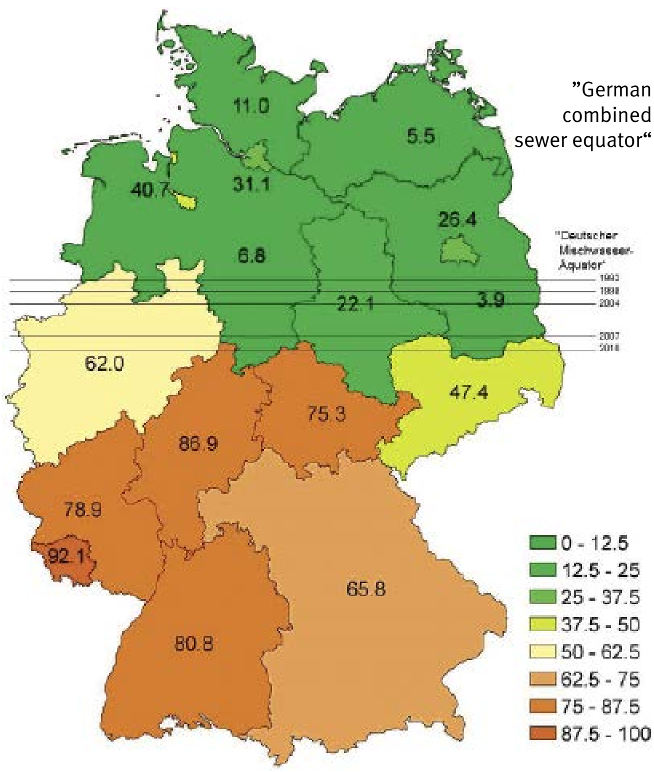

Fig. 3: Proportion of the population connected to combined sewer systems in % at the end of 2010

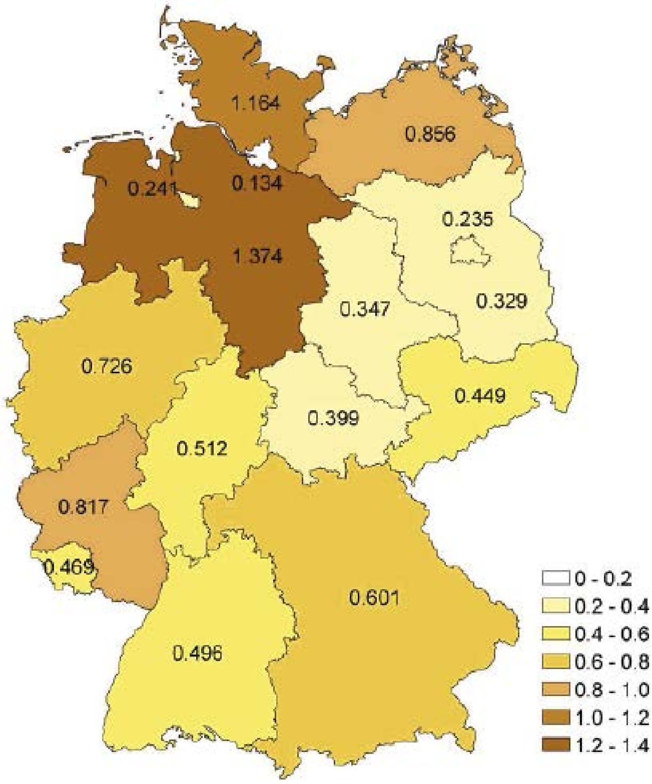

Fig. 4: Storage volume for stormwater in the public sewage system, in m³ per head of population at the end of 2010

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

Why this should be the case in Germany, and why it is still increasing, has long been passionately debated, and will not be examined here any further; refer to [5]. But anyone who follows the publications and discussions must always weigh up whether "lowland" or "highland" is being discussed, since quite different drainage philosophies, often unspoken, lie behind them.

9 Stormwater tanks

According to DWA-A 166 [16] a distinction is made in the combined sewer system between stormwater tanks with overflow (STO), sewers with storage capacity and overflow (SSCO), retention soil filter basins (RSF) and stormwater retention facilities (SRF), while in the separate sewer system the distinction is between stormwater sedimentation tanks (SST), retention soil filter basins (RSF) and stormwater retention facilities (SRF). The Federal Statistical Office has only partially adopted this classification. It does not list any sewers with in-line storage capacity and overflow, although these are tacitly included under the heading of stormwater tanks with overflow. It is not clear which of the stormwater retention facilities should be 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. In order to simplify this assignment for the reader, the top line of Table 1 has been supplemented with "CSys" and "SSys" for combined and separate systems respectively.

In columns 10 to 15, Table 1 shows the existing number of storm tanks and their storage 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 for the year of recording 2010, the total for Germany is an impressive 47,678 (1998: 31,044; 2004: 41,569; 2007: 45,457) with a total volume of 53,880 million m³ (1998: 33,143; 2004: 46,753; 2007: 52,259), see columns 16 and 17.

If the retention volumes of stormwater tanks created over the last 35 years or more in the public sewage system (not including the volumes of the retention soil filter basins, which are not included in the count, without adding the silent retention volume of stormwater overflows (SO), and without the natural retention of the flowing wave) are divided arithmetically, evenly across the country's inhabitants, the numbers illustrated in column 18 of Table 1, with which Figure 4 was prepared, are obtained.

At the end of 2010, a federal average of 0.659 m³/inhabitant of artificially created storage volume for the retention of stormwater was present (2004: 0.567; 2007: 0.635). This corresponds to a growth of 24 litres over three years, or 1.2% per year.

If we assume a mean construction expense of €1000 per cubic metre of storage volume, then the development of rainwater treatment has cost each federal citizen €659 – even if he hasn't noticed it. At first sight this may look like a lot of money, but when divided over the last 35 years, the expense comes out at just about €20 per head per year.

With the present consumption of drinking water of around 121 litres per head per day, then in theory the retention volume in the public sewage system now present would be enough to store domestic wastewater for 5.4 days – if there is no rain, and if there is no infiltration water.

10 Infiltration and inflow (I/I) water

Infiltration and inflow (I/I) water primarily comprises clean groundwater that penetrates through leaking sewage pipes, or rainwater which unintentionally finds its way into the sanitary sewers of the separate sewer system.

The amount of I/I water varies greatly from year to year, seasonally within any one year, and locally. From practical and scientific points of view, it is in fact not at all easy to draw conclusions about the annual I/I rate from the measured input to wastewater treatment plants. The Federal Statistical Office nevertheless has asked since 1987 for the annual flow of sanitary sewage, stormwater and infiltration water into all of Germany's wastewater treatment plants.

The "infiltration rate" of Figure 5 is the amount of I/I water, expressed in %, entering the wastewater treatment plants each year in addition to the sanitary sewage. In 2010, the federal average of the I/I rate was 45.9% (2004: 34.8%; 2007: 40.3%). Figure 5 is highly inconsistent. The state of Berlin has not provided any figures on I/I water for years. Five of Berlin's wastewater treatment plants are located in Brandenburg – Berlin has "outsourced" the handling of infiltration water. In Hessen, the infiltration rate is 17.5 times larger than it is in Brandenburg. Why are there such glaring differences?

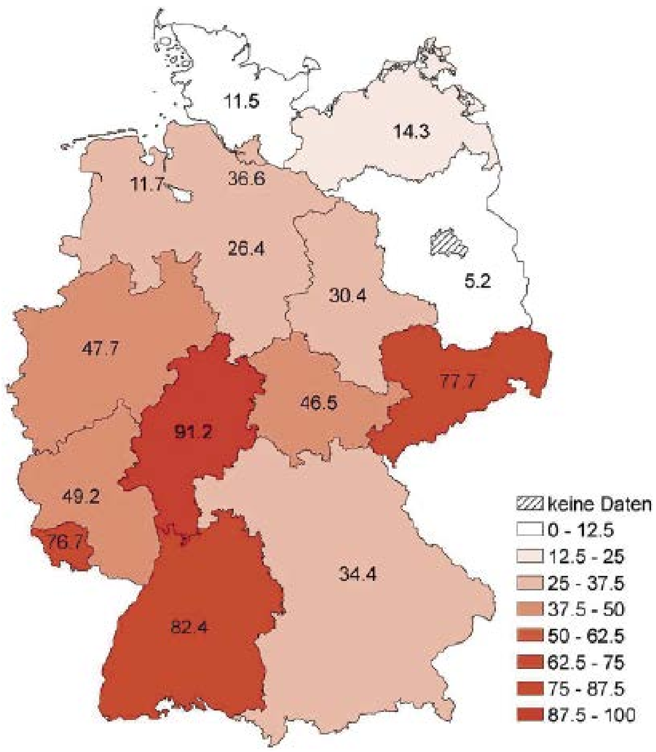

Fig. 5: Mean infiltration/inflow (I/I) rate as a % of sanitary sewage flow throughout 2010

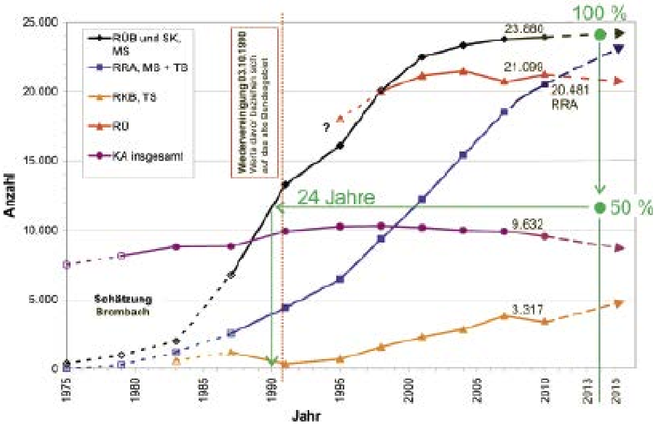

Fig. 6: Development of the number of rainwater treatment facilities of all kinds over time

The author suspects, that the amount of infiltration water is determined using different methods (annual sanitary sewage method, night minimum method, methods with sliding minimums) and with different purposes (wastewater fees) in the various federal states, or is even simply estimated. The new DWA-M 182 code of practice on the topic of I/I water [17], 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 I/I water statistics valid across the country.

Even though some of the numbers illustrated in Figure 5 may be doubted, the overall picture is alarming. With the high rate of connection to the sewage system and to wastewater treatment plants, and with the ongoing 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 I/I water, and the DWA-M 182 code of practice [17] deliberately does not set a maximum limit, but mean annual I/I rates of more than 50% indicate a need for action.

11 The development of stormwater treatment facilities over time

Figure 6 shows curves for the number of significant components involved in the treatment of stormwater over the period from 1975 to 2013. Satisfactory data sources have only been available since reunification of Germany in 1990. The author has reconstructed earlier times from sources [1–3]. The development following the last census in 2010 is a prediction.

The retention soil filter basins (RSF), 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 6. The data was unfortunately not collected, and this gap in recording should be closed as soon as possible.

11.1 Stormwater tanks with overflow and sewers with in-line storage capacity and overflow

According to the official figure, there were 23,880 stormwater tanks with overflow and sewers with in-line storage capacity and overflow, with a total volume of 14.978 million m^3, at the end of 2010. The mean storage capacity of each basin was 627 m^3. As can clearly be seen in Figure 6, the period from 1987 to 1998 was a phase of vigorous construction of stormwater tanks with overflow and sewers with in-line storage capacity and overflow. Since the last-but-one census in 2007, only 108 more stormwater tanks with overflow and sewers with storage capacity and overflow have been built in the whole of Germany. The total storage volume even fell a little! The first phase of stormwater treatment in the combined system, the creation of retention volumes, is largely completed. Only a few more new constructions will be undertaken.

It must not, however, be overlooked that about half of the STOs and SSCOs presently in use are more than 24 years old! Many of the old designs no longer correspond to today's standards, regulations and knowledge, and 40% of all STOs, which is nearly 10,000 of them, have a noticeable tendency to heavy overflow activity [18]. In many cases, spare parts are no longer available for the technical equipment, and in particular for the electronic controllers. Rather like wastewater treatment plants, it should be assumed that renovation of the construction and thorough refurbishment of the engineering equipment will be necessary in a cycle of around 25 years. The second phase of the central rainwater treatment in the combined system, the renovation and optimisation of existing constructions, is already in full swing.

11.2 Stormwater retention facilities

In 2010, the count showed a stock of 20,481 stormwater retention facilities; since 2007, nearly 2000 have been added. With a volume of 36,211 million m^3, they have now more than overtaken the existing total artificial retention volume in combined sewers! At just about 1800 m^3, the mean volume of the stormwater retention facilities is three times greater than that of the stormwater tanks! In Figure 6, the SRF curve has a slightly lower gradient after 2007. It would appear that the new construction of stormwater retention tanks is entering the saturation phase.

Practical experience shows, that a large number of new stormwater retention facilities are being built on state and federal roads and on autobahns. The author has suspected for some time that many of these installations are not being included in the DESTATIS statistics. A check of random samples in North Rhine-Westphalia showed that this is indeed not yet happening. These installations are not categorised as "public" wastewater treatment plants. This gap in recording should be closed as soon as possible.

11.3 Stormwater sedimentation tanks

The 3317 stormwater sedimentation tanks with clarifier overflow in the storm sewer of the separate system means that they are relatively rare. The latest "bump" in 2010 is most likely due to a change in the method of counting. The mean volume of the stormwater sedimentation tanks is 810 m^3. There is a question as to whether the stormwater sedimentation tanks in the road and autobahn drainage system, see Chapter 11.2, have actually been included in the data collection.

11.4 Combined Stormwater overflows

The stormwater overflows in the combined system (CSOs) have only been recorded statistically since 1998. The author has serious doubts about the latest figure of 21,099 such overflows. 300 new stormwater overflows are supposed to have been built since 2007, but in the same period there are only 100 new stormwater tanks with overflow. Is it possible, that old emergency outlets of doubtful status under the water statutes have been re-declared as new stormwater overflows?

11.5 Public Wastewater treatment plants

The number of official wastewater treatment plants in Germany reached a maximum of 10,312 in 1998, and then dropped slowly but continuously back to 9632 in 2010; see column 20 in Table 1. The combination of multiple small treatment plants into larger storm water treatment plants is a reasonable trend which should continue, or even be reinforced.

12 Conclusion and outlook

In October 2013, the German Statistical Office presented new, complete and official data about the type and scope of public sewage system and storm water treatment in Germany for the year 2010.

It became clear in the middle of 2013, that the population figures are smaller than had been previously assumed. In the next census from the Federal Statistical Office in 2013, the specific figures related to inhabitants, such as for example the drain length or the reservoir volume per head, will take a jump upwards.

In the middle of 2010, the proportion of the population of the federal republic connected to the public sewage system stood at 96.6%. The new federal states still have a small backlog. At 95.5%, the rate of connection in Germany to wastewater treatment plant with second and third purification stages is in fourth position behind the Netherlands, Great Britain and Switzerland when compared internationally [14].

The federal average is 6.87 m of public sewer length per citizen (Figure 7). 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 54.7%. The ironically intended “German combined sewer equator” has again moved southward, lying now on the line between Dortmund and Göttingen.

In 2010 Germany had in total an impressive 47,678 stormwater tanks, with a total volume of 53,880 million m^3. For each

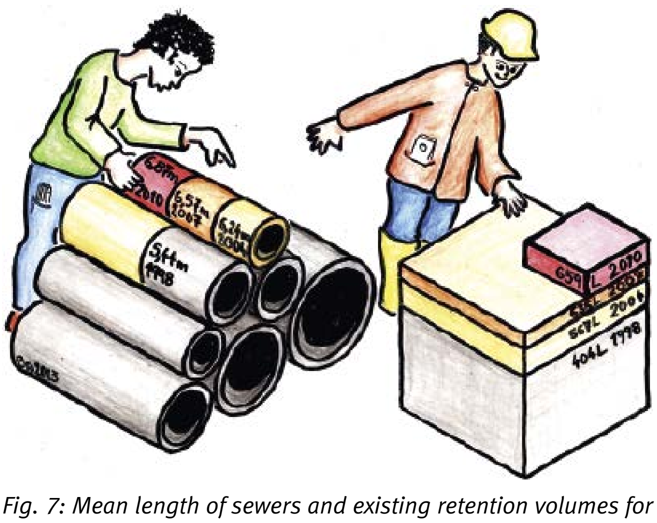

Fig. 7: Mean length of sewers and existing retention volumes for stormwater retention in the public sewage system per head of population at the end of 2010

inhabitant, 0.659 m^3 of artificially created storage volume for the retention of wastewater during rain was available.

The federal average for 2010 of the infiltration rate had an annual mean of 45.9%. The high level of infiltration/inflow rate – more than 50% in some federal states – is alarming. Something must be done to standardise infiltration/inflow water statistics valid across the country.

The number of public wastewater treatment plants in Germany has fallen slowly but continuously since 1998 to 9632 in 2010. This is a plausible trend.

The retention soil filter basins (RSF), 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 6. The data was not collected, and this gap in recording should be closed as soon as possible.

Many stormwater tanks on state and federal roads and autobahns are not categorised as "public" wastewater treatment plants, and until now have not been included in the federal statistics, or not completely.

There is an urgent need for action in the management of the water statistics! The cycles of years in which the federal states provide situation reports, and the years when the German Statistical Office collects data should be harmonised, and the situation reports should be matched to one another.

The first phase of water treatment in the combined system, the creation of storm retention volumes, is largely completed, and there will only be a few new constructions. The second phase of the central rainwater treatment in the combined system, the renovation and optimisation of existing constructions, is already in full swing.

On the whole, the treatment of rainwater in the public urban drainage systems has made great progress, without which the evident improvement in the water quality in Germany would not have been possible.

Thanks

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References

[1] Brombach, H.: Regenüberlaufbecken im Spiegel der Statistik, *Korrespondenz Abwasser* 1979, *26* (10), 601–605

[2] Brombach, H.: Mehr als 8000 Regenüberlaufbecken in Betrieb! *Korrespondenz Abwasser* 1988, *35* (12), 1286–1291

[3] Brombach, H., Kuhn, B.: Häufigkeit und Verteilung der Kanalisationsverfahren in Deutschland, *Korrespondenz Abwasser* 1992, *39* (8), 1106–1112

[4] Brombach, H.: Abwasserkanalisation und Regenbecken im Spiegel der Statistik, *Korrespondenz Abwasser* 2002, *49* (4), 444–452

[5] Brombach, H.: Abwasserkanalisation und Regenbecken im Spiegel der Statistik, *Korrespondenz Abwasser* 2006, *53* (11), 1114–1122

[6] Brombach, H.: Im Spiegel der Statistik: Abwasserkanalisation und Regenwasserbehandlung in Deutschland, *Korrespondenz Abwasser* 2010, *57* (1), 28–32

[7] Statistisches Bundesamt: *Umwelt, Öffentliche Wasserversorgung und Abwasserentsorgung nach Ländern, Anschlussgrad und Wasserabgabe 2010*, erschienen 9. November 2012, korrigiert 31. Januar 2013

[8] Statistisches Bundesamt: *Umwelt, Öffentliche Wasserversorgung und öffentliche Abwasserbehandlung und -entsorgung 2010*, Fachserie 19, Reihe 2.1.2, erschienen 5. August 2013

[9] Statistisches Bundesamt: *Umwelt, Öffentliche Wasserversorgung und öffentliche Abwasserentsorgung – Strukturdaten zur Wasserwirtschaft 2010*, Fachserie 19, Reihe 2.1.3, erschienen 7. Oktober 2013

[10] Richtlinie des Rates vom 21. Mai 1991 über die Behandlung von kommunalen Abwasser (91/271/EWG), *Amtsblatt der Europäischen Gemeinschaften*, L 135 vom 30. Mai 1991, 40–52, geändert durch die Richtlinie 98/15/EG vom 27. Februar 1998, *Amtsblatt der Europäischen Gemeinschaften*, L 67 vom 7. März 1998, 29–30

[11] Rheinland-Pfalz, Ministerium für Umwelt, Landwirtschaft, Ernährung, Weinbau und Forsten: *Stand der Abwasserbeseitigung in Rheinland-Pfalz, Lagebericht 2012* (mit den statistischen Zahlen von 2010)

[12] Hessen, Ministerium für Umwelt, Energie, Landwirtschaft und Verbraucherschutz: *Beseitigung von kommunalen Abwässern in Hessen, Lagebericht 2012*

[13] Statistisches Bundesamt: Zensus 2011, Tabellenband zur Pressekonferenz am 31. Mai 2013 in Berlin

[14] Organization for Economic Co-operation and Development (OECD), Environment Directorate: *OECD Key Environmental Indicators 2008*, *www.oecd.org/env/indicators-modelling-outlooks/37551205.pdf*

[15] 23. DWA-Leistungsvergleich kommunaler Kläranlagen 2010, *Korrespondenz Abwasser* 2011, *58* (10), 914–918

[16] Arbeitsblatt DWA-A 166: *Bauwerke der zentralen Regenwasserbehandlung und -rückhaltung – Konstruktive Gestaltung und Ausrüstung*, Hennef, 2013

[17] Merkblatt DWA-M 182: *Fremdwasser in Entwässerungssystemen außerhalb von Gebäuden*, Hennef, 2012

[18] Brombach, H.: Zentrale Regenwasserbehandlungsanlagen – Vergangenheit und Zukunft, Vortrag, 12. DWA-Regenwassertage in Freiburg-Munzingen, 2013

[19] Brombach, H.: Im Spiegel der Statistik – Abwasserkanalisation und Regenwasserbehandlung in Deutschland, *Korrespondenz Abwasser* 2013, *60* (12), 1044–1053

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25th Performance Comparison of Municipal Wastewater Treatment Plants in Germany

Treatment Processes Put to the Test
25 Years of Performance Comparison of Wastewater Treatment Plants

The idea of a performance comparison of wastewater treatment plants dates back more than 25 years. Due to the significance of wastewater treatment for water pollution control, treatment plant performance has been documented since the end of the 1980ies. Already back then it was important to demonstrate the state of the art of wastewater treatment in Germany to the public as well as wastewater treatment experts. In addition the comparison of plant performance was meant to motivate operating personnel and to heighten their awareness for contributing to the advancement of wastewater treatment standards.

Already in 1986 the DWA Committee 5.4 "Wastewater Treatment Plant Neighbourhoods" decided to establish a standard method, which enabled a nationwide comparison. For the first time in 1988 a nationwide performance comparison was conducted and published. Starting with the year 1993 also the new Federal States participated. Since the assessment criteria

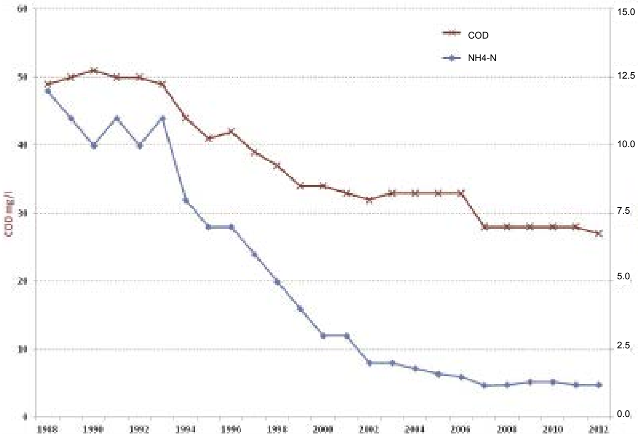

Fig. 1: Development of average values of COD and NH_4-N concentrations in wastewater treatment plant effluent between 1988 and 2012

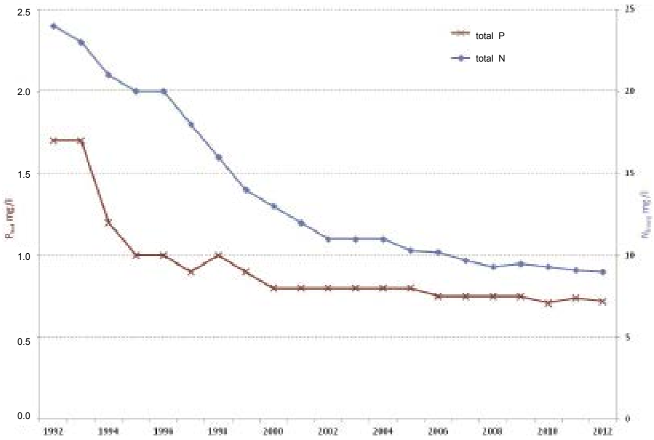

Fig. 2: Development of average values of total N and P concentrations in wastewater treatment plant effluent between 1988 and 2012

established back then are still valid today, development of wastewater treatment over the years can be documented on the basis of the results of these performance comparisons (see Figures 1 and 2).

Especially in the first years, the improvement of purification efficiency of wastewater treatment plants was clearly visible and could be demonstrated for each Federal State Association on the basis of the performance comparison. The upgrading of wastewater treatment plants to advanced wastewater treatment proceeded and nutrient concentrations as well as COD and BOD_5 concentrations in the treatment plant effluents decreased continuously. In the beginning of the year 2000 the major part of the construction works had been completed and working with the new treatment processes had become standard for the operating personnel.

In the years after the new Federal States had joined in the performance comparison, all parameters improved significantly on account of upgrading and adapting wastewater treatment plants of the Federal State Associations North/East and Saxony/Thuringia to the state of science and technology. The striking improvement of effluent quality for the parameters COD, NH_4-N, total N and P_{tot} could be observed by the nationwide average values. Altogether now after 25 years an **excellent effluent quality** can be attested. By now applied treatment processes have mostly reached their performance limit. Thus, only little additional improvements of purification efficiency could be realized during the last 5 years. Further improvements will only be possible, if more advanced treatment processes are used (e. g. activated carbon, ozone).

Starting with the year 2006, additional reports concerning specific topics were compiled using the extensive data material collected nationwide by monitoring of operation and self-monitoring. So far the following topics have been covered:

- Influent concentrations and degrees of degradation (2006)
- Data analysis according to riversheds (2007)
- First analysis on electric power consumption (2008)
- Phosphorus removal (2009)
- Nitrogen removal (2010)
- Detailed nationwide analysis of electric power consumption (2011)
- Comparison of treatment processes (2012)

Analysis of current developments will continue in the future in order to provide incentives for optimizing operation of wastewater treatment plants in order to be able to meet increasing treatment requirements. Thus, if possible additional key figures such as electric power consumption and other significant parameters are to be collected and analysed. Then the annually conducted performance comparison could also be used for e.g. performing an energy check of each individual wastewater treatment plant. This shows that the "Performance Comparison of Wastewater Treatment Plants" is not a closed issue, but continuously needs to be improved and adapted to new questions arising in the field of wastewater treatment.

1 Objectives and Fundamentals of the Nationwide Performance Comparison

The DWA performance comparison demonstrates the quality of wastewater treatment and shows the amount of electric power consumed for wastewater treatment. It also reflects and honours the qualified work of the operating personnel. Data of this performance comparison were collected by the DWA Associations of the Federal States and for the first time were analysed in regard to treatment processes.

According to the German Federal Statistical Office, 95 % of the population were connected to municipal wastewater treatment plants in the year 2007. Altogether 9.933 municipal wastewater treatment plants exist in Germany with a treatment capacity of 151.3 million population equivalents (PE). 5,914 treatment plants with a capacity of 142.6 million PE participated in the 25th DWA Performance Comparison. On account of the record-breaking participation of 94.2 %, results for the year 2012 can be considered representative for Germany. Basis for the comparison are 3.6 million individual measurements, which have been taken by the operating personnel within the self-monitoring programmes and are used as annual mean values for the assessment.

The assessment was conducted as before structured according to DWA Associations of the Federal States and according to treatment plant size category (SC). The distribution of wastewater treatment plants in regard to treatment capacity and number of plants is shown in Figure 3. Just 4 % of the wastewater treatment plants have a treatment capacity > 100,000 PE (SC 5), but at the same time these treatment plants represent 52 % of total treatment capacity.

2 Results

Table 1 shows the results of influent and effluent measurements (load-weighted mean values), degrees of degradation and other parameters as well as data on participation. For the first time also results of the ÖWAV performance comparison of wastewater treatment plants in Austria and South Tyrol were included. One has to keep in mind that the ÖWAV performance comparison also covers industrial wastewater treatment plants (pulp and paper, pharmaceutical and leather industry), the effluent of which contains large amounts of hardly degradable COD.

In comparison to the previous year, slight improvements of effluent concentrations can be observed, degrees of degradation show no significant changes. Noteworthy are higher degrees of degradation of N and P for the State Associations North and North-East, which are due to a significantly higher pollution of the influent. The reason for this among other things lies in the separate sewer systems, which are much more common in those federal states. As a consequence, influent pollution in those federal states is higher on account of separate discharge of stormwater. Effluent values for total P are somewhat lower in Austria/South Tyrol, which is due to higher legal requirements for phosphorus removal (P precipitation starting at 1,000 PE).

Overall also in the year 2012 on the nationwide average requirements of the EU guidelines for municipal wastewater were met or significantly exceeded. Nevertheless, some treatment plants remain which still need to be adapted to the state of science and technology (sewer system and wastewater treatment plant).

As a reference number for calculating specific wastewater flow and specific consumption of electric power, mean wastewater treatment plant load in PE was determined by the mean COD influent load. For calculation a specific COD load of 120 g/(PE×d) was assumed.

Specific wastewater flow showed no significant changes compared to the previous year. For the DWA State Associations North and North-East specific wastewater flow is considerably lower, which is again presumably due to the separate collection systems more common in these regions.

As in 2011, data on electric power consumption were again collected in all State Associations. Specific consumption of electric power (kWh/(PE×a) could be calculated for 5,095 wastewater treatment plants. The lowest values were obtained

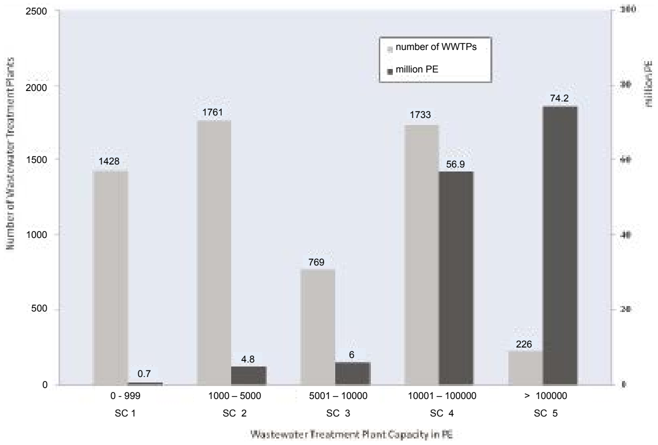

Fig. 3: Wastewater treatment plants which participated in the DWA performance comparison in 2012

for Austria/South Tyrol and the State Associations of Saxony/Thuringia, the highest values were determined for the State Associations North-East and North Rhine-Westfalia (NRW).

3 Comparison of Purification Processes

3.1 Wastewater Treatment

The activated sludge process is the most common treatment process (81 %) used at wastewater treatment plants independent from size category. Only a small number of plants uses trickling filters (7 %). Aerated and non-aerated lagoons (11 %) as well as constructed wetlands (1 %) are with few exceptions only used at plants in size category 1 and 2. Furthermore multi-stage treatment plants often use a combination of various purification processes

The following data analysis only covers those single-stage treatment plants, which could be assigned unambiguously to one of the following treatment processes:

- Activated sludge process with anaerobic sludge stabilization (ASD)
- Activated sludge process with aerobic sludge stabilization (ASS)
- Activated sludge process with discontinuous step-feed inflow (SBR)

DWA State Association	Baden-Württem-berg	Bavaria	Hesse/ Rhine-land-Pa-latinate/ Saarland	North	North-East	North Rhine-West-falia	Saxony/ Thuring-ia	DWA Total	ÖAWV* Total
Wastewater Treatment Plants (number)	955	1609	1445	567	300	513	528	5917	906
annual wastewater flow (million m^3)	1594	1588	1423	838	503	2355	489	8789	197
capacity (million PE)	21.6	26.6	18.4	22.2	13.1	32.2	8.5	142.6	27.3
mean load /PE (million PE	16.4	19.9	15.8	16.2	11.5	22.9	7.2	109.9	17.9
capacity PE/mean load PE	1.32	1.34	1.17	1.37	1.14	1.41	1.18	1.30	1.52
spec. wastewater flow [m^3/(PE×a)]	97	80	90	52	44	103	68	80	67
spec. electric power consumption [kWh/(PE×a)]	33.0	32.2	33.9	34.2	37.6	36.6	31.6	34.3	31.4
COD influent (mg/L)	451	550	487	849	1003	427	645	548	656
effluent (mg/L)	21	28	24	38	42	24	31	27	43.8
degree of degradation (%)	95.3	94.9	95.0	95.5	95.9	94.3	95.2	95.1	93.3
total N** influent (mg/L)	42.8	51.9	48.1	71.1	86.4	41.4	58.4	51.0	43.2
effluent (mg/L)	9.6	10.1	9.0	8.9	11.2	7.3	10.2	9.0	8.9
degree of degradation (%)	77.7	80.6	81.3	87.4	87.0	82.3	82.6	82.3	79.4
total P influent (mg/L)	6.7	8.1	7.3	11.7	14.4	6.0	9.2	7.9	7.5
effluent (mg/L)	0.64	0.97	0.90	0.64	0.61	0.48	1.00	0.72	0.65
degree of degradation (%)	90.5	88.0	87.7	94.5	95.7	91.9	89.2	90.9	91.3
NH_4-N effluent (mg/L)	0.76	1.40	1.64	1.29	1.32	0.93	1.58	1.19	1.20
NO_3-N effluent (mg/L)	7.1	6.7	5.2	5.6	8.0	4.9	6.2	6.0	5.7

* Austria + South Tyrol including industrial wastewater treatment plants
** total N = N_{inorg} + N_{org}

Table 1: Mean influent and effluent concentrations, degrees of degradation and parameters

- Trickling filters (TF)
- Lagoons non-aerated (L)
- Lagoons aerated (LA)
- Constructed wetlands (CW)

Data were analyzed according to treatment process and treatment plant size category. For calculation of mean values only size categories with at least 10 treatment plants were considered. All in all complete data sets were available for 3,219 plants (Table 2).

As shown in the following diagrams, differences in efficiency can indeed be found between the various analyzed treatment processes. Activated sludge plants have lower COD concentrations in their effluent than trickling filters and lagoons (see Fig. 4). The COD concentration values in the effluent of constructed wetlands lie in between. The same effect can be observed for COD degradation (see Fig. 5), where activated sludge plants achieve a COD removal of 94 – 96 %, trickling filters and lagoons achieve 86 – 92 % and constructed wetlands accomplish almost 93 %.

For nitrification (see Fig. 6) best results are also obtained at activated sludge plants (0.5 – 2.1 mg NH_4-N/l) followed by trickling filters (2.1 – 3.5 mg NH_4-N/l), constructed wetlands (8.2 mg NH_4-N/l) and wastewater lagoons (9.7 – 16.0 mg NH_4-N/l). It is remarkable that aerated lagoons show poorer effluent values than non-aerated lagoons.

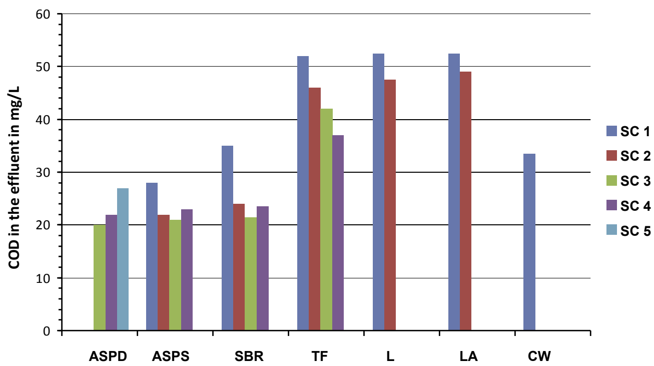

Fig. 4: COD concentrations in the effluent in dependency on treatment process and treatment plant size category (SC)

The highest rate of nitrogen removal is achieved by SBR reactors (87 – 92 %) and by activated sludge plants using aerobic sludge stabilization (83 – 91 %). Nitrogen removal rate for

Treatment plant size category	Capacity [PE]	ASD	ASS	SBR	TF	L	LA	CW
SC 1	0 – 999		220	57	87	233	125	59
SC 2	1,000 – 5,000		581	63	146	20	147	
SC 3	5,001 – 10,000	37	318	22	34			
SC 4	10,001 – 100,000	526	381	30	20			
SC 5	> 100,000	113						
Total		676	1.500	172	287	253	272	59

Table 2: Number of analyzed wastewater treatment plants classified according to treatment process and treatment plant size category (SC)

	ASD	ASS	SBR	TFD	L	LA	CW
	specific electrical power consumption in kWh/(PE×a) *(number of plants)*						
SC1		**65.2** *(184)*	**92.8** *(45)*	**53.2** *(65)*	**23.8** *(45)*	**41.5** *(44)*	**19.1** *(26)*
SC2		**44.2** *(476)*	**44.4** *(46)*	**22.7** *(119)*		**35.6** *(123)*	
SC3	**37.9** *(37)*	**39.4** *(269)*	**50.2** *(19)*	**24.7** *(28)*			
SC4	**33.8** *(509)*	**36.2** *(345)*	**35.2** (27)	**26.5** *(15)*			
SC5	**31.9** *(114)*						

Table 3: Specific electrical power consumption of analyzed wastewater treatment plants (mean values) in regard to treatment process and treatment plant size category (SC) in kWh/(PE×a) – (in parentheses: number of plants)

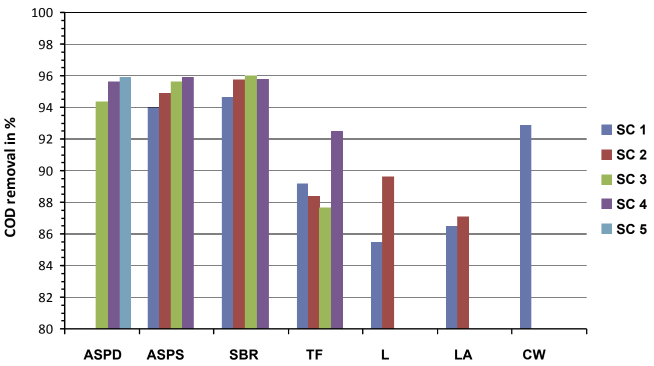

Fig. 5: COD removal in the effluent in dependency on treatment process and treatment plant size category (SC)

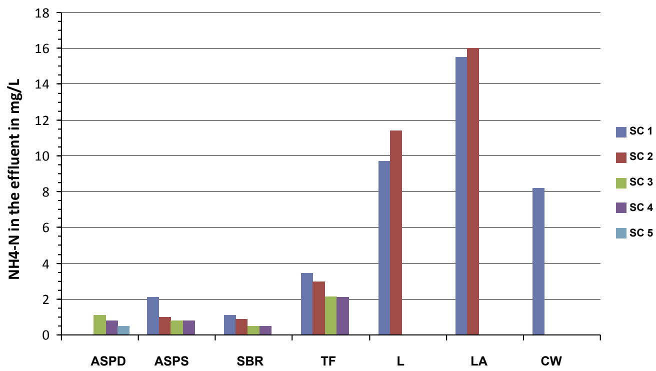

Fig. 6: NH_4-N concentrations in the effluent in dependency on treatment process and treatment plant size category (SC)

plants with anaerobic sludge stabilization increases considerably from 73 to 85 % with increasing plant size category. All other treatment processes only achieve degrees of degradation of about 60 % (see Fig. 7) on account of incomplete denitrification.

3.2 Consumption of Electrical Power

While in the year 2011 electrical power consumption was analysed in regard to wastewater specific influences, such as specific wastewater flow, specific nitrogen load in the influent as

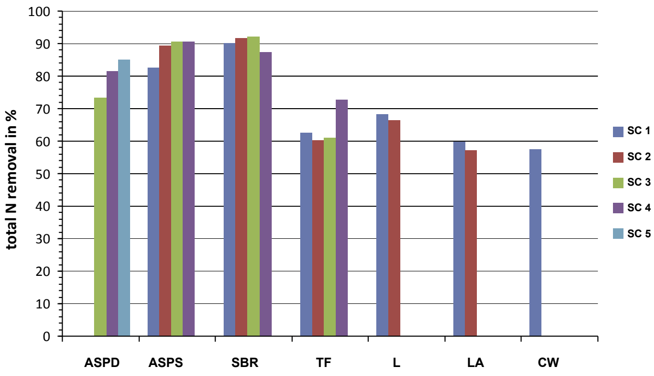

Fig. 7: Total N removal in dependency on treatment process and treatment plant size category (SC)

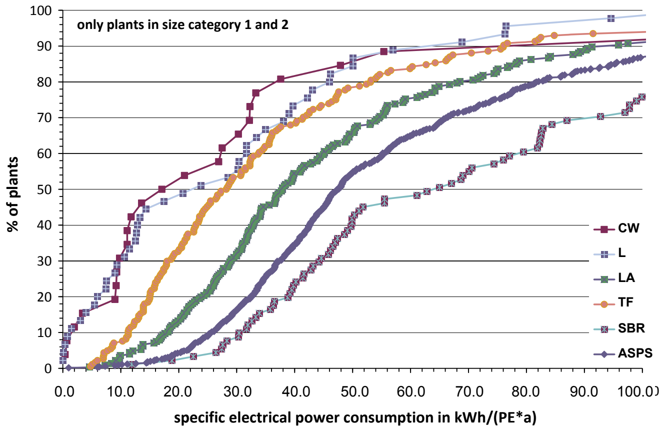

Fig. 8: Specific electrical power consumption in dependency on the treatment process for treatment plants in size category 1 and 2 (< 5,000 PE)

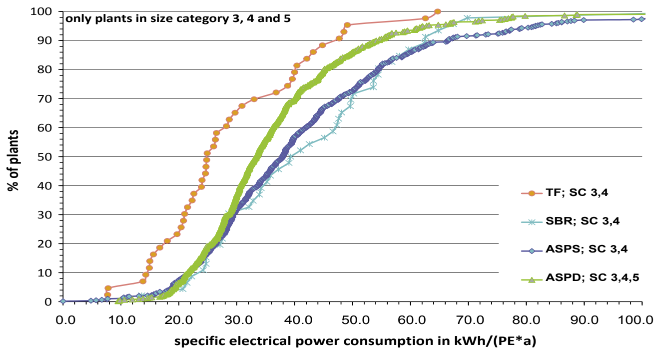

Fig. 9: Specific electrical power consumption in dependency on the treatment process for treatment plants in size category 3, 4 and 5 (> 5,000 PE)

well as organic load, the performance comparison of the year 2012 focussed on the investigation of electrical power consumption in regard to the various treatment processes used. In Table 3 the number of analyzed treatment plants (in parentheses) and the mean values of the individual treatment plant size categories are compiled for each treatment process.

As expected, the lowest specific electrical power consumption in treatment plant size category 1 was observed for constructed wetlands and non-aerated lagoons. Trickling filters plants also consume less electrical power than activated sludge plants, however, in contrast to the trend observed for other treatment processes, here specific electrical power consumption increases slightly with increasing plant size category.

Significantly higher specific electrical power consumption was determined for aerated lagoons in comparison to non-aerated lagoons, but determined values remained below values found for activated sludge plants, which at plant capacities below 5,000 PE normally use simultaneous aerobic sludge stabilization.

Among the activated sludge plants, plants with anaerobic sludge stabilization (size category 3 and above) have the lowest specific electrical power consumption, plants with aerobic sludge stabilisation come in second. It is remarkable that only a slight difference exists between the two treatment processes. Comparably high values can be found for SBR plants. This is probably due to the more energy-intensive combination of aeration and mixing and to the mostly required lifting of wastewater.

In order to illustrate the range of individual results, cumulative frequency distribution was analyzed. On account of the general dependency of specific electrical power consumption on treatment plant capacity, a distinction was drawn between treatment plants with a capacity below 5,000 PE (treatment plant size category 1 and 2) and plants with a capacity above 5,000 PE (treatment plant size category 3, 4 and 5) (see Fig. 8 and 9).

Although the individual results lie within a wide range of 0 kWh/(PW×a) and in part significantly above 100 kWh/(PE×a), it an be observed that the applied treatment processes have a considerable influence on electric power consumption.

Above a capacity of more than 5,000 PE constructed wetlands and lagoons (non-aerated and aerated) are only used in particular cases and are thus not included in the further evaluation. Activated sludge plants with separate anaerobic sludge stabilization (sludge digestion) in contrast are used increasingly above a capacity of 5,000 PE.

Plants using trickling filters generally consume considerably less electrical power in comparison to activated sludge plants. However, those trickling filter plants which are specifically laid out for nitrogen removal, consume more than 35 kWh/(PE×a) of electric power, apparently on account of increased recirculation of the wastewater. Plants using simultaneous aerobic sludge stabilization and SBR plants consume basically the same amount of electric power, if they have a capacity of more than 5,000 PE.

4 Conclusion

Compared to the previous years participation in the nationwide DWA Performance Comparison could be increased even more in 2012. Special thanks go to the operating personnel of municipal wastewater treatment plants for their cooperation and support. The results draw a representative picture of purification efficiencies of German wastewater treatment plants. 5,917 wastewater treatment plants with a capacity of 142.6 million PE participated in 2012.

For the first time also respective data for Austria including South Tyrol supplied by the ÖWAV were integrated in the comparison. To a large extent, results match data of German wastewater treatment plants.

Furthermore, nationwide data on electric power consumption at wastewater treatment plants were collected and evaluated statistically. On the average, a specific electric power consumption of 34.3 kWh/(PE×a) was determined. The present electric power consumption per person lies at a little more than 1,000 kWh/(PE×a). This shows that less than 4 % of the annual power consumption of a household (or a person) is attributed to wastewater treatment. The goal of wastewater treatment is to achieve the highest possible purification level at the lowest possible power consumption. Thus, it goes without saying that energy should not be wasted in the field of wastewater treatment. Using energy checks and energy analyses it should be possible in the future to properly evaluate electric power consumption of wastewater treatment, to identify unnecessary surplus consumption and to introduce measures for minimizing consumption of electric power where necessary.

In the year 2012, for the first time a comparison in regard to treatment processes has been conducted. The best purification results were found for the waste activated sludge process, the treatment process used predominantly in Germany. The best effluent values were determined for the SBR process. This process, however, consumes more electrical power. Trickling filter plants, wastewater lagoons and constructed wetlands, all of which are used predominantly in size categories 1 and 2, can only achieve a nitrogen removal rate of 60 %. It is remarkable that electric power consumption of trickling filter plants in contrast to other processes increases slightly with increasing plant size.

Overall also in the year 2012 on the nationwide average requirements of the EU guidelines for municipal wastewater were met or significantly exceeded. Nevertheless, some treatment plants remain which still need to be adapted to the state of science and technology (sewer system and wastewater treatment plant). Also the treatment of wastewater from combined sewer systems should increasingly be brought into focus in the future.

A general need for action could arise at wastewater treatment plants in the years to come on account of legal regulations for a fourth treatment step, which is required for the elimination of trace pollutants in the wastewater. Currently, extensive tests are carried out in this field.

The DWA Working Group BIZ-1.1 Wastewater Treatment Plant Neighbourhoods would like to thank all participants, instructors and chairmen of wastewater treatment plants neighbourhoods for their support in data collection and analysis. Without them this nationwide performance comparison would not have been possible.

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On the road from wastewater disposal to recycling and resources management?

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Recent publications and declarations on the development of the water management sector increasingly raise the question whether wastewater should not also be considered as a resource, just like water. The current debate on phosphorus recovery or energy recovery potentials in the water management sector automatically leads to the thought that wastewater, like waste, is not only a "residual" that must be disposed of, but a recyclable material. But we must always bear in mind that there is one major difference between wastewater and waste. Even if we attribute a higher value to wastewater because several of its ingredients are recyclable, the "water treasure" is first of all determined by its contents of "unpolluted water". Thus priority must be given to treating our water resources and keeping them clean over recovery methods for recycling other raw materials contained in the wastewater.

Key words: wastewater, recyclables, resource, phosphorus recycling

1 Wastewater: defining terminology and location

In the middle ages, the German word for wastewater (*Abwasser* in present-day German, or *afwater* in Middle High German) was already in use, although it wasn't part of everyday speech at that time. Even then, the word referred to wastewater that could not be used. The use of the term became more common in the 19th century, in connection with the more intensive concern with epidemics and with hygienic problems arising from the shortcomings of wastewater management. The development of the engineering industry, and the increased production of large quantities of wastewater, played an important part here.

In that context, the word had a rather negative, pejorative sense: above all, the concern was with contamination caused by water usage. All the same, the more or less purposeful handling of wastewater is an important part of human history. There is evidence from antiquity of the development of large settlements and cities with water supply and wastewater disposal systems. Both the use of faeces as a fertiliser and of urine as a tanning agent played a part since early times – we could say that the idea of recycling already existed.

For a variety of reasons, this understanding of the systematic handling of wastewater became largely lost after the middle ages. That, in addition to the rapid development of cities, is one of the causes for the sometimes catastrophic hygienic conditions, and the associated spread of serious epidemics.

The enormous pressure presented by this problem led, in the 19th century, to the planned and systematic consideration of wastewater disposal. As a result of the serious hygienic problems, the focus was initially on the fastest and most complete possible drainage of the wastewater, and the attempt to discharge it as far as possible. In the more recent past it also became an objective to protect waterways from contamination, for instance through further development of biological water treatment to eliminate nutrients and oxygen-consuming substances [1]. Nowadays, the term "wastewater" is the object of definitions in statutes and in sub-legal standards. According to Section 54, Para. 1 of the Water Resources Act, wastewater is water whose properties have been changed by domestic, commercial, agricultural or other usage, and the water (sanitary sewage) that is discharged together with it in dry weather, as well as the precipitation collected by built-up or paved areas and discharged from them (precipitation water).

The fluids generated when storing and treating garbage are also a form of sanitary sewage. In a similar way, DIN 4045 (2003) defines wastewater as water that has been changed, in particular contaminated, flowing away after domestic or commercial use, and water originating in precipitation and entering into the sewage system. The contamination of the clean, natural water thus continues to be a focus of attention under this terminology.

The fact that this understanding of the terms is characterised by the idea of disposal is also illustrated by the heading "Wastewater disposal" of the corresponding sections in the federal and state water regulations. According to Section 54, Para. 2 of the Water Resources Act, wastewater disposal particularly comprises the collection, transport, treatment, introduction, seepage, irrigation and sprinkling of wastewater. As a supplement to this, Section 51 Para. 3 of the North Rhine-Westphalia state water act specifies that a wastewater treatment plant is equipment whose purpose is to minimise or overcome the harmful effects of the wastewater. This also includes plant whose task is to prepare the sewage sludge generated in connection with wastewater treatment for proper disposal. The idea of the "end of the pipe" lurks behind this, and does not seem far away from the saying, "out of sight, out of mind".

2 From disposal thinking to utilisation thinking

The development of the water law indicates an ongoing internal differentiation in the content of the idea of wastewater: precipitation water, for example, although it continues to be thought of as a component of the wastewater in addition to the sanitary sewage, is considered specifically through the regulation in Sect. 55, Para. 2 of the Water Resources Act. According to this, precipitation water should be allowed to seep away close to its original site, sprinkled, or directly introduced to a waterway without mixing with sanitary sewage. The standard mentions a dedicated precipitation water drain (separate system) as a further option. The target approached by this regulation, that of directly passing clean precipitation water to the ground and thereby to the groundwater or to the waterways, if possible without using any wastewater transport or treatment plants, is on the one hand aimed at the idea of a return to the natural water cycle. This standard indicates on the other hand that it is possible for individual "water currents" not only to be subject to different regulations, but also in reality to be handled differently from the point of view of water resources management.

To that extent, there are approaches to further differentiations. According to ISO 6107-7 (2006), "black water" is domestic wastewater containing faecal matter. The black water is further distinguished into: 1. yellow water, a general term for urine and urine with flushing water, and 2. brown water. That is the portion of the wastewater that only contains faeces, flushing water and toilet paper. Pure brown water is created by separating toilets that separate urine and faeces. "Grey water" refers to wastewater that is somewhat dirty, but does not contain faeces, generated for example by showering, bathing or washing hands, or that emerges from the washing machine and is suitable for treatment to provide process service or process water.

It can be seen that behind these attempts at a definition, an effort is being made to distinguish between different wastewater components, from the point of view of different forms of treatment, or even of later utilisation (perhaps as fertiliser). The large amount of literature relating to wastewater terminology in water statutes [2] also illustrates how the understanding of wastewater and its treatment is becoming increasingly more differentiated. The property of being wastewater will end when, for instance, through processing or through usage it is seen as economic goods or as part of economic goods.

Today's wastewater system thus has the goal of transporting the wastewater as quickly as possible away from the (water) user and (wastewater) generator, and of purifying it before returning it to the water cycle. Wastewater treatment involves the use of mechanical, chemical, physical and biological methods to remove the materials contained in the wastewater, as far as possible and necessary, and to return the water that has been cleaned in this way to the waterways [3]. The pollutants – or, better, the wastewater contents – can in part be distinguished, on the basis of the requirements and possibilities of today's wastewater treatment plants, as

- oxygen-consuming substances (e.g. uric acid, which is biodegradable while consuming oxygen),
- nutrients (in particular compounds of nitrogen and phosphorus),
- contaminants (e.g. grease, oil or sand), and
- pollutants (e.g. heavy metals, chemicals or medication residues).

These differentiations again have the primary purpose of advancing the process of wastewater treatment through a systematic consideration of the materials it contains.

The understanding of an integrated or integral water management system, as is to an extent expressed in the Water Framework Directive, should in any case lead to the understanding that wastewater is not a left-over that must finally be disposed of, but is a "temporary state" of the water within its cycle. From this point of view, materials contained in wastewater, or the "loading" of the water with heat, can be understood not just as an unwanted condition, but also as something with a potential for exploitation and as a raw material. This applies to nutrients such as phosphorus as well as to energy in the form of biomass (sewage sludge), (wastewater) heat, or kinetic or hydrostatic energy. The question of whether more use should not be made of these potentials in wastewater than has been the case in the past is growing in importance.

One factor that comes into play here is that modern wastewater treatment uses considerable quantities of energy and auxiliary materials (e.g. dewatering agents). Yet another factor is that, in spite of high cleaning standards and significant financial expenditure, some of the said substances enter the waterways as "micro-contamination" or as "trace materials", leading to discussions of further purification techniques ("the fourth purification stage").

3 Wastewater as a resource

The question of whether wastewater itself represents a resource is being increasingly discussed [4]. In entirely general terms, resources are stocks of materials that are necessary for a particular purpose, in particular for feeding humanity and for commercial production. The public and political discussion is paying particular attention to those natural resources that are components or functions of nature with economic value. Land, water and air, as well as raw materials found in nature, which must be transported and in many cases purified but which do not have to be manufactured, are counted as natural resources. In terms of sustainable policies, an increasing effort is being made to see that the use of natural resources does not significantly exceed the earth's capacity for regeneration (see the resources efficiency programme of the German federal government issued on 29.2.2012 [5]).

Natural resources are important production factors that can be represented in monetary terms in the sense of ecosystem services (c.f. for example the Millennium Ecosystem Assessment [6]). They are the foundations of human life, often only available to a limited extent, and not in every case renewable. At the same time, the use of raw materials through the entire value chain (production, processing, use and disposal) generally involves environmental considerations which can include the release of greenhouse gases, the emission of contaminants into water, ground and air, as well as considerations of ecosystems and biodiversity. The sparing and efficient use of natural resources is therefore increasingly seen as one of the central challenges of the future. The federal government wishes to pursue these targets systematically through its resources efficiency programme.

3.1 Saving and reusing water

Germany is fundamentally a water-rich country, with plenty of water available. Thus in 2007, according to figures from the Federal Statistical Office, the 32 billion m^3 of water drawn were less than 20% of the available water resources. The greater part of this, 20 billion m^3, was taken by cooling water for power stations. At 5.1 billion m^3, public water supplies used less than 3 percent of the available water. About two thirds of this went to households and small businesses. Over the same period, the quantity of sanitary sewage passed to the wastewater system, at about 5.2 billion m^3, was much the same as the amount of drinking water supplied.

Over the last twenty years, careful and efficient water usage has allowed the amount of water drawn and water consumption in Germany to drop significantly. Most importantly, recirculation systems in industrial and commercial fields have meant that the amount of water withdrawn has fallen by more than 30 percent. To this extent, there is no shortage of water as a resource in Germany, and, as far as we presently understand the effects of climate change, this is unlikely to alter greatly. Should shortages develop in some limited regions in future, in particular as a result of seasonal variations, this can be handled by modified extraction and distribution systems on regional and national levels.

Thus from the points of view of water management and of resources shortage, there is no great need to save water. However, as a result of rising costs and as a consequence of technological development, it can be expected that multiple usage of water, and the management of water and wastewater in circulation systems in commerce and industry, will intensify. On top of this, a careful approach to water as a natural resource is appropriate for ethical reasons. See, for example, Augustin et al. [7] on the use of grey and black water in residential areas with reference to the example of the HAMBURG WATER Cycle (Jenfelder Au).

At the same time we should note that existing water and wastewater systems require a certain throughput in order to function properly. If the water consumption were to fall below these minimum quantities, the result would be that water would have to be added for flushing and cleaning the system – this is already a reality in remote regions of Germany as a feature of demographic change.

In regard to the repeated criticism of central wastewater systems and of so-called water-borne sewage systems, it must be said that for the large agglomerations of population in industrialised countries, there is no foreseeable, technically and economically reasonable alternative. It is precisely the uninterrupted function of this infrastructure that has given us a significant improvement in the "public health", and has made a marked contribution to the increase in life expectancy.

For this reason, water recycling will in the long term only have a very limited significance for us. Nevertheless, available water resources in other parts of the world are, due to natural conditions, significantly less, and climate change may lead to a further reduction.

It is therefore important for both pure science and practical engineering to look at the question of the extent to which purified wastewater can be used to replace drinking water and groundwater for the irrigation of agricultural areas, in order to ensure an adequate supply of drinking water in these other countries. This also reflects the fact that we import "virtual water" from other countries, not least in the form of agricultural produce. This so-called "water footprint", the water that we use through our imports from other countries, must be included, as an additional measure for the sustainability of the use of water resources, in the discussion [8].

3.2 Recovering the contents of wastewater

The management of water quantities in Germany is a permanently necessary task, but one that can be easily fulfilled. Bearing in mind the variety of ways in which water is used and the effects of materials it may contain, water quality management, which implies securing a lasting good quality of the available water, presents a serious challenge. In this context it can be interesting to bring more advanced wastewater treatment technologies, amongst other things for the elimination of micro-contamination, into the discussion, since it is possible that substances that at present are considered primarily as pollutants and toxins in wastewater, may in future also become important from the point of view of raw materials recovery. A few examples:

Phosphorus. Phosphorus is an altogether important resource, having fundamental importance to the growth and function of organisms. Flora and fauna, and of course also human beings, are dependent on a continuous supply of this material. Large quantities of fertiliser containing phosphorus are used in agriculture, and it is also necessary for many industrial processes.

As far as we know today, the best-known phosphorus deposits contain only limited reserves, which can be economically extracted using today's technology. There are, nevertheless, very different estimates as to what other phosphorus deposits may be available, and whether a grave shortage of phosphorus can be foreseen. The main deposits are located outside Germany. Heavy metal pollution and extensive excavation mean that their exploitation presents risks to people and the environment. For this reason, intensive scientific and practical efforts are being made over the recovery of phosphorus from waste materials.

Wastewater and sewage sludge offer the greatest potential for phosphorus recovery. In principle, the phosphate contained in sewage sludge can be returned to the cycle effectively through its agricultural use. However, as a result of the concerns about the presence of pollutants in sewage sludge, it appears likely that its agricultural use will in future fall further. For this reason investigations are under way into the extent to which different process technologies could recover the phosphorus contained in wastewater and sewage sludge, and convert it to a form that is low in pollutants and usable by plants. Due to the growing proportion of thermal exploitation of sewage sludge, the question of how the quantities of phosphorus contained in sewage sludge combustion ashes can be secured for future utilisation is being discussed. To that extent, the retrievable storage of the ashes in mono-fill sites or special sections of landfill sites is valuable, for as long as it is not yet technically and commercially possible to process them to form phosphates that are low in pollutants and usable by plants. The possibility of recovering phosphorus from existing sewage sludge stores and dumps, a kind of "urban mining", should also be examined.

Precious metals. In its resources efficiency programme, the federal government states that ashes from the combustion of sewage sludge should be stored in dumps for future use, not only because of the phosphorus, but also because of other raw materials contained in them, important metals in particular. Wastewater thus carries valuable freight; the importance of technologies for recovering these kinds of valuable materials is therefore growing. In addition to other materials used by humans, precious metals can also be analytically detected in wastewater. This includes, for example, elements of the platinum group, together with ruthenium, rhodium, iridium and platinum. German hospitals are believed to release between 30 and 100 kg of platinum annually in wastewater. The mechanical and thermal wear in motor vehicle catalytic converters adds about another 300 kg to that. The presence of other precious metals, such as gold and silver, can also be detected both in wastewater and in sewage sludge.

Silver, in particular, is finding applications in more and more fields: in sanitation as nanosilver for disinfection, for the conservation and sterilisation of water, and also for the impregnation of fibres and as a coating agent, not least because of its antibacterial action. In addition to a growing range of medical applications, silver is found in cooling and process fluids because of its strongly fungicidal and bactericidal effects. Estimates suggest that in 2010, about 8200 kg of silver were used in Germany for these and other purposes – see here also [9].

Copper. Dissolved copper is, on the one hand, viewed as a toxic content of wastewater. At the same time, however, it is also a valuable resource. The removal of copper from industrial wastewater has therefore long been an important topic for wastewater technology. Reducing the copper concentration below permitted limits is not the only issue at stake here. As the price of raw materials rises, recovery policies also play an increasing role.

Since wastewater has been understood as a resource of energy and of valuable materials, more and more consideration has been given to the question of how wastewater should be treated and valuable materials recovered in a manner that is both technically and commercially viable. As well as large companies such as Siemens, start-up firms such as Magpie Polymers in France are also looking at processing technologies that can recover even small traces of valuable materials from the wastewater. The extent to which this is not only relevant for the treatment of industrial and commercial wastewater, but also significant for the recovery of valuable materials from municipal and domestic wastewater, depends to a very large extent not only on technological development, but also on trends in costs and the market situation.

In addition to the recyclable materials just mentioned, other products can be extracted from the wastewater, e.g. biologically degradable, resources-saving *bioplastics* (polyhydroxyalkanoates, PHA) in the Brussels North wastewater treatment plant [10].

3.3 Energy from wastewater

Finally, the exploitation of the energy contained, in particular, in the organic contents of the wastewater is becoming ever more important. Thus wastewater treatment plant is no longer solely a consumer of energy, but is also a place for its production from regenerative sources. Above all the biomass contained in the sewage sludge has an important function here. The energy potential contained in the sewage sludge has been used for a long time now in wastewater treatment plants with anaerobic sludge stabilisation in digestion tanks. The digester gas that is generated here is exploited as the heat for combined heat and power plants, and equipment for power-heat cogeneration [1].

Hydrogen can be produced through electrolytic conversion of the digester gas. In the wastewater treatment plant at Emscher-Mitte in Bottrop, digester gas is already being converted to hydrogen in the framework of the "EuWaK" ("Erdgas und Wasserstoff aus Klärgas" – "Natural gas and Hydrogen from Digester Gas") project [11]. The hydrogen generated from the digester gas is used to provide power and heat to a school complex, including a swimming bath, located close to the Bottrop wastewater treatment plant. The EuWaK project thus represents the first large-scale engineering implementation of a treatment plant converting digester gas to gaseous hydrogen for extensive future purposes (PEM fuel cells), in combination with natural gas as a bridging technology. By processing digester gas to provide gas of the quality of natural gas and hydrogen, wastewater treatment plants can develop from pure disposal companies into production companies for high-quality energy sources.

As biomass and as a source of regenerative energy, the sewage sludge itself gains considerable importance to the realisation of wastewater treatment plants that are self-sufficient in energy. The use of the sewage sludge in biomass power stations associated with water management makes a significant contribution to the production of its own energy. This does more than allow a substitute for fossil fuels; it is also possible for the CO_2 emissions involved in generating the energy required for modern wastewater treatment plants to be significantly and sustainably reduced. If we bear in mind that, from the point of view also of environmental protection, the primary goal is the thermal exploitation of sewage sludge, the associated energy generation plays a part that should not be overlooked. One great advantage of wastewater treatment plants is the possibility of energy storage – as digester gas in existing gas containers, or as a sewage sludge fuel in stackable containers. This storage possibility, along with an intelligent coordination and control of the very different plants, creates a "smart area net" [12].

All the same, sewage sludge will still not be seen, either legally or terms of material handling, in the same light as other kinds of biomass, in particular biomass from agriculture. As a result, it is compared unfavourably with agricultural biogas plants, albeit for no comprehensible or substantive reasons. This creates obstacles that get in the way of the intelligent utilisation of the potentials for co-fermentation with other biological residues that exist in the wastewater treatment plant digestion tanks. They could be used to make significant additional contributions to the regenerative production of energy in simple, safe, economical ways, in existing plants and with professionally competent personnel.

There is also an option for the future of significantly advancing the generation of energy in the plant itself on the basis of biomass that it has produced. In addition, the plant can develop its own biomass as an energy source through breeding microalgae in the wastewater treatment plant. Everything that algae need (next to the sunlight needed for photosynthesis, which can in some cases also be substituted by artificial light) is available in wastewater treatment plants with nutrient-rich wastewater. The additional biomass generated in such microalgae systems can be exploited for energy in existing plants. This can considerably increase the energy yield by the production of gas and its thermal exploitation. Microalgae can moreover, process nutrients and other components of wastewater, making a contribution to optimising the wastewater treatment and to the elimination of certain specific wastewater contents [13].

Perhaps the most direct form of exploitation of the energy of wastewater is to use the wastewater heat. Depending on its temperature and on a uniform temperature progression, wastewater represents an ideal heat source for the operation of heat pumps, which can be operated all year round with good efficiency. Exploitation of wastewater heat using the heat exchanger principle is applied to sewer networks.

An analysis of potentials, and maps of available heat, are important instruments for local utilisation [14].

4 The comparison with the solid waste management

The examples illustrate how the principle of recycling management is becoming more important for the efficient utilisation and protection of natural resources in the management of water and wastewater. This extends and supports the goal of ensuring the protection of human beings and the environment when handling wastewater. These principles are, however, scarcely found in the legal foundations for wastewater disposal, even though water regulations are fundamentally oriented around the natural water cycle. At best, recycling and resources management are mentioned peripherally in the legal text.

On the other hand, the Recycling and Waste Management Act of 24 February 2012 (legislation on the advancement of recycling management and ensuring the environmentally sustainable management of waste) has now brought in extensive additional regulations. Whereas policies of disposal took centre stage in traditional waste management, waste is nowadays perceived as a recyclable material, a raw material and as a source of energy, since waste can – like the contents of wastewater – replace natural resources. As a result of the increasing price of raw materials, and the limited availability of fossil energy sources, the significance of waste as a source of both raw materials and energy has grown. Rather than waste disposal, the exploitation of waste in material or energetic ways plays the crucial role. The Recycling and Waste Management Act recognises this, and already expresses it, in that Section 1 of the act defines recycling and resources management as the central aim. This pushes to the fore the legislative aim of achieving a sustainable improvement in environmental and climate protection, and the efficient use of resources through a reinforcement of waste avoidance and through the recycling of waste. The heart of the act, moreover, is the new, five-level waste hierarchy (Section 6 of the Recycling and Waste Management Act). This lays down a sequence of levels, comprising waste avoidance, reuse, recycling and other exploitation of waste including for energy purposes, finishing with waste disposal. Priority is given to the best option in each case from the points of view of environmental protection and sustainability. For this reason, technical, economic and social consequences must be borne in mind, in addition to the ecological effects [15].

Waste and recycling management is thus aimed in the first place at avoidance and at recycling. An important element of the thinking surrounding recycling management is product responsibility (Section 23 of the Recycling and Waste Management Act). According to this, whoever has developed, manufactured, processed or sold products carries the product responsibility for fulfilling the aims of recycling management. Products should be designed as far as possible in such a way that their manufacture and their use avoids the creation of waste, and so that it is ensured that after use, the waste that is created can be exploited or disposed of in an environmentally sound manner. Precisely this standard raises the question of why product responsibility should come to an end, when the use of products does not create solid waste, but creates instead wastewater contents of a comparable type – according to Section 11 of the statute, the more so as the principles of recycling management apply to sewage sludge (such as bio-waste).

5 Prospects

It remains to be seen whether "wastewater treatment plants are unexploited goldmines", as asserted by the title of DIE WELT online [15]. Nevertheless, it is now beyond doubt that they do offer potentials for the recovery of resources and for the production of regenerative energy.

Exploitation for energy is to a large extent possible with today's technical possibilities in existing water management plants. Future technologies, such as hydrogen production and fuel cells, could further reinforce this.

Even if the potentials for energy concerned are limited when set against Germany's total energy requirement, regenerative energy production and its direct exploitation in wastewater treatment plants can yet make an almost nationwide contribution to the trend for decentralised energy revolution. It is strategically significant that, as a result, wastewater treatment plants can be perceived not only as disposal sites, but also as components in the energy and raw material recovery system. It is important that the exploitation of the energy potentially available in wastewater is supported politically and through legislation, and not impeded by being burdened with levies and taxes, or through discrimination when compared to agricultural energy plants.

The recovery of valuable materials – such as precious metals – from the wastewater is, in contrast, not yet the "state-of-the-art". The work with appropriate technologies, which has already begun, should be continued, and linked more closely with the topic of "elimination" of wastewater contents. More in-depth investigations should aim to determine the potentially usable quantities of valuable materials in wastewater more precisely and with greater differentiation. Since no technically or commercially convincing methods yet exist even for recovering phosphorus, the storage of sewage sludge combustion ashes in separate dumps, or ash dumps, is however a reasonable approach to securing potential raw materials in the long term.

In this context, however, it should also be remembered that there is one vital difference between wastewater and solid waste: If we ignore the potentials for exploiting the valuable raw materials it contains, solid waste is, after all, "rubbish": it is a residue for disposal. Wastewater on the other hand consists in the first place of an altogether valuable resource: water. Even if, as a result of a range of valuable contents, the wastewater is seen to have a greater value than it was accorded in the past, the value of water is yet primarily determined by the "uncontaminated water" that it contains.

To treat this in such a way that the fundamental resource obtained can be returned again to the water cycle is the core task of wastewater treatment as a component of recycling and resources management. Processes for recovering other raw materials from the wastewater must therefore give priority to purifying, and maintaining the purity of, water resources. This is for the protection of waterways, and of the living beings, in particular people, who depend on them.

To the extent that it is helpful to pursue the ideas of the material cycle and of resources management in water and wastewater management more systematically, the legal regulations of the water statutes must be scrutinised, and updated where necessary. Especially in the light of modern solid waste legislation, we should consider whether an increased product responsibility and a consideration of the life-cycle should not also cover the contents of wastewater, in particular since it can be seen as a raw material.

If the recovery of raw materials from wastewater is to play a more important role in the future, then questions that are presently discussed in the context of solid waste management will also become relevant to wastewater management: the question, for example, of who owns the valuable contents in wastewater, which at present are only thought of as a problematic and costly contamination. This example illustrates how the path from wastewater disposal to recycling and resources management can scarcely be imagined without a far-reaching paradigm change for the wastewater management system.

References

[1] Steinmetz, H. (2012): *Abwasser – Rohstoff statt Reststoff*. In: Themenheft Forschung. Wasser und Umwelt 8/2012. Universität Stuttgart (Hrsg.): S. 34–42.

[2] Czychowski, M., Reinhardt, M. (2007): *Wasserhaushaltsgesetz unter Berücksichtigung der Landeswassergesetze*. Kommentar. 9. Auflage. München (C. H. Beck): S. 1495.

[3] Stemplewski, J., Ruppert, J. (Hrsg.) (2011): *Unser Wasser von A bis Z*. Ein Lexikon zur Wasserwirtschaft. München (Oldenbourg Industrieverlag). S. 24.

[4] Kroiss, H. (2013): *„Nachhaltiger Umgang mit Ressource"*, In: Schriftenreihe GWA – Band 232, 46. ESSENER TAGUNG für Wasser- und Abfallwirtschaft „Ressourcenschutz als interdisziplinäre Aufgabe" vom 13.–15.03.2013 in Aachen, Beitrag 2/1-11, Hrsg. J. Pinnekamp.

[5] Deutsches Ressourceneffizienzprogramm (2012): *Deutsches Ressourceneffizienzprogramm (ProgRess). Programm zur nachhaltigen Nutzung und zum Schutz der natürlichen Ressourcen*. Beschluss des Bundeskabinetts vom 29.2.2012. Hrsg. V. Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU). Berlin: S. 113.

[6] Millennium Ecosystem Assessment (2005): *Ecosystems and Human Well-being: Synthesis*, Washington D.C., S. 39 ff.

[7] Augustin, K., Meinzinger, F. & Skambraks, A.-K. (2013): *Hamburg Water Cycle in der Jenfelder Au*. Special Abwasser Dezentral 1–2/2013: S. 10–12.

[8] Sonnenberg, A.,Chapagain, A. & Geiger, M. & August, D. (2009): *Der Wasser-Fußabdruck Deutschlands*, WWF Deutschland (Hrsg.). Frankfurt am Main. S. 13 ff.

[9] Hund-Rinke, K., Marscheider-Weidemann, F., Kemper, M. (2008): *Beurteilung von Gesamtumweltexposition von Silberionen aus Biozid-Produkten.* UBA-Texte 43/08, Berlin.

[10] Kraus, S. (2013): *Kunststoff aus Abwasser*. Veolia Umweltmagazin 1/2013, Special Ressourceneffizienz. Berlin. S. 24–25.

[11] Schulte, P., Jagemann, P. & Teichgräber, B. (2011): *Demonstrationsprojekt EuWaK – Erdgas und Wasserstoff aus Kläranlagen*. In: Tagungsband des 18. Energiesymposiums „Nutzung regenerativer Energiequellen und Wasserstofftechnik" an der Fachhochschule Stralsund (3.–5.11.2011). S. 182–192.

[12] Stemplewski, J. (2012a): *Das Hybridkraftwerk Emscher in Bottrop: Energiepotenziale der Wasserwirtschaft nutzen!* In: Korrespondenz Abwasser, Abfall (4). Hennef. S: 325–329.

[13] Stemplewski, J. (2012b): *Crossover – neue Optionen für die Wasserwirtschaft durch interdisziplinäres Denken und Handeln*. Korrespondenz Wasserwirtschaft (5/2012). Hennef. S: 274–277

[14] Becker, M., Treis, A. & Weilandt, M. (2010): *Abwasserwärmenutzung – Projektentwicklung, Erfahrungen und Herausforderungen bei der Umsetzung*. In: Zukunftsthema Energie. Die Siedlungswasserwirtschaft ist gefordert. Schriftenreihe Siedlungswasserwirtschaft Bochum Nr. 61. S. 79–97.

[15] Schink, A. & Versteyl, A. (Hrsg.) (2012): *Kommentar zum Kreislaufwirtschaftsgesetz.* Berlin, S. 14–17 ff.

[16] von der Weiden, S. (2011): *Klärwerke sind unerschöpfte Goldgruben*. In: Welt online: http://www.welt.de/wissenschaft/article13492904/Klaerwerke-sind-unerschoepfte-Goldgruben.html (Abruf: 15.8.2013). Berlin.

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10 years of international DWA resolution – an interim balance

Rüdiger Heidebrecht (Hennef, Germany), Robert Schmidt (Munich, Germany) and Gabriele Martens (Hennef, Germany)

The report describes examples of DWA's internationally oriented activities over the last 10 years, and is limited to a selection of important projects. At DWA's federal conference in Wolfsburg in 2003, the general meeting passed a resolution on reinforced international engagement on the part of DWA. What has been done? What goals is DWA pursuing? Why is this sector so important to the future? The article provides answers, and describes the strategy of DWA in this field.

1 Introduction

The principle of "International cooperation" (extract)

"The DWA has strengthened its international engagement. It supports global targets for access to clean drinking water and the creation of sustainable wastewater treatment plants. It also supports the development and application of environmentally friendly, resource-saving solutions for the waste management sector. … The multi-sided, and successful, experience developed in Germany should be made more internationally available, and its use enhanced. … The DWA supports the economy's international engagement. It collaborates in the formulation of exhibition conference programmes, and supports the exhibition companies in their engagement abroad…"

2 DWA committees

The BIZ-11 Technical committee

The BIZ-11 International Cooperation Committee has existed since 1988, and so celebrated its 25-year anniversary in 2013. The committee began with DWA's involvement in the organisation of IFAT. Originally started in 1956 as a DWA conference event with an accompanying exhibition, it was taken over by the Munich trade-fair company Messe München, taking on the form of an exhibition with an accompanying conference.

Various working groups within the technical committee are concerned with regional issues – south-east Europe for example – and on particular topics, such as Expoval (dimensioning of wastewater treatment plants in hot and cold climate zones) and GAWN (German Alumni Water Network).

3 Internationalisation of standards and regulations (SaR)

In the formerly strong national embossed SaR system European and international standards (CEN and ISO) are gaining importance. Since 1994, the DWA therefore involved in European standardization and co-developed this as part of the "New Approaches of the European Union". These activities have been necessary with the development of the European internal market (single market) in order to harmonize methods of water management proven in Germany with neighboring countries and to be able to develop their own standards of efficiency and environmental effects. Today, around 240 wastewater-related CEN-standards form an integrated system of standards with the rules of the DWA.

DWA supports its members in their foreign activities, acting as a "door-opener", and helps market entry through making translated standards and regulatory documents available, not only in English, but also in many other languages. More than 100 translated publications, mostly standards and regulations, were available in 13 languages at the end of 2013, and the number continues to rise.

4 The significance of exhibitions

IFAT

IFAT has developed into the world's largest environmental exhibition, and into an important marketplace for international activities, meetings and business for the members of DWA. DWA is a partner of Messe München, which organises IFAT. It organises a programme of conferences and seminars, technical outings for exhibition visitors, welcomes delegations from abroad, and much else.

Wasser Berlin International

DWA organises the international country forum at the biennial trade fair Wasser Berlin International.

Messe München's activities

In 2004, Messe München (MMG) organised the first IFAT China, as an "offshoot" of the Munich IFAT, in Shanghai. DWA was responsible for the technical/scientific conference programme, which accompanies the exhibition. This event has taken place annually since 2012, and has changed its name to IEexpo. Working together with the National Engineering Research Center for Urban Pollution Control at Tongji University in Shanghai, a programme of conferences on four important topic groups was planned and executed, as well as a "Young Water Programme" for each of 100 student participants.

IFAT Mumbai

IFAT has taken place in Mumbai annually since 2013. It is planned that in 2014, the exhibition will be accompanied by a conference programme planned by DWA.

5 Young Water Professionals Programme (YWP)

Since 2001, a week-long programme of visits and outings to international events in Germany for 50 young international engineers or engineering students has been held, in most cases to Wasser Berlin or to IFAT in Munich. More than 600 participants from more than 50 countries have taken part in the programme so far. The programme of exhibition visits has been enriched by outings, conferences (Young Water Conference), career advice sessions, and time spent in the "Young Water Lounge".

6 Professional competition/ WorldSkills International

A conference was organised in 2013 on vocational training and competence development with UNESCO/Unevoc at WorldSkills Leipzig. German water management was represented at this event with a demonstration competition.

7 Federal Ministry for Economic Cooperation and Development (BMZ – Bundesministerium für Wirtschaftliche Zusammenarbeit)

World Water Week

At World Water Week, which takes place annually in Stockholm, DWA appeared jointly with Messe München 2013. The topic was cooperation in the water sector between UN organisations and politics (Federal Ministry of the Environment, Federal Ministry for Economic Cooperation and Development, German Society for International Cooperation, KfW (government-owned development bank), Federal Institute for Geosciences and Natural Resources).

Cooperation with the German Society for International Cooperation (GIZ)

In 2007 a cooperative project was begun with what was then known as DED (German Development Service), resulting in comprehensive training in preparation given to aid workers in the water sector being sent to emerging and developing countries. This cooperation merged into the cooperation with the GIZ. The collaboration with the InWEnt – Capacity Building International was also integrated into this. A variety of measures for international junior management in the water sector was planned and executed.

8 Cooperation with UN organisations

Cooperation with the UN Water Decade Programme on Capacity Development has been proceeding since 2008; this has resulted in a variety of international activities, such as the Organisation of International Water Loss Conferences, and appearances at IFAT.

Joint events related to the internationalisation of professional education take place together with UNESCO Unevoc. A common publication appeared in 2012: Skills Challenges in the Water and Wastewater Industry.

Furthermore, the DWA supports selectively UNHABITAT Global Water Operators' Partnerships Alliance (GWOPA) with the aim to involve operators more into aid for developing countries.

9 Cooperation with the German Water Partnership (GWP)

DWA assists on the advisory board of GWP as well as in a range of regional forums, south-east Europe, for example. DWA managed the Jordan/Egypt regional forum for some time. DWA is/was active in the Turkey, China and India regional forums. There was an increased engagement in the Capacity Development working group. We refer to the publication of this working group: Capacity Development in the Water Sector – German Experiences and Offers for Global Water Management (Capacity Development im Wassersektor – Deutsche Erfahrungen und Angebote für die Wasserwirtschaft weltweit).

Within the framework of a study trip organised by DWA, delegations from Turkey visited various members of GWP, who arranged a topic workshop for the delegation.

The China regional forum organised a block of GWP-DWA presentations in the exhibition forum for IE Expo 2013.

10 A few sample projects

DBU Poland/Czech Republic/Hungary

Between 1998 and 2002, the DBU (German Federal Environmental Foundation) supported a knowledge transfer project with the associations in Poland, the Czech Republic and Hungary. Joint conferences and expert exchange trips took place; regulatory documents were translated, as were specialist articles in the trade publications.

ACWUA and Engicon

As a result of the existing cooperation with DWA member Engicon in Jordan and the marketing partner, it was possible to hold 34 courses involving 545 participants in the MENA region in 2012 and 2013. DWA prepared the trainers, ensured quality and provided support on technical issues.

TCC Croatia

The training centre in Karlovac was supported by "training the trainers".

TBB Turkey

In 2006, technical trips to the German Water Management Organisation were organised for mayors from the Turkish Association of Towns and Municipalities. TBB saw to the translation of the German-English-Turkish technical dictionary.

GIZ Bangladesh

Cooperating with GIZ in Dhaka, the curriculum was developed for a training programme for the qualification of personnel in industrial wastewater treatment plants in the textile industry, and was implemented as a pilot scheme. In addition, the Ministry of the Environment was advised about the requirements for a sewage sludge directive.

Courses in English

The topics of "Membrane Technology", "Project Cost Assessment" and "Management in Wastewater Treatment Plants" were amongst those handled in week-long seminars whose participants represented an international clientele.

Technical safety management in Egypt

From mid 2009 on a quality management tool for water utilities was developed by the Egyptian Holding Company for water and waste water (HCWW) and GIZ with the support of DWA and DVGW (German Technical and Scientific Association for Gas and Water). The procedure of "Technical Sustainable Management" enables water- and wastewater plants to improve their performance in organizational, safety and operational issues. Since 2010, more than 25 plants were successfully certified in accordance with national standards and requirements.

International course on association establishment

In 2012, a course concerning the establishment of a water management association was held for association representatives from south-east Europe, including Albania, in order to reinforce the position of the associations in that region.

Delegations

Through customised programmes related to their particular issues, a large number of international delegations were accompanied on excursions, or were prepared theoretically and guided in practice, to solve a range of organisational and technical problems.

Teaching and learning material (DWA Didactic)

DWA offers the magnetic kits with educational material related to wastewater treatment plants, biogas plants and the environmental field, in various languages for use in further education and training.

11 Commercial perspective

In the context of globalisation, DWA offers manifold support to its internationally active members through its international services:

- Technical dictionaries in various languages
- Participation in exhibitions at home and abroad
- A large number of technical publications in English
- Customised specialist programmes for delegations
- Consultation and service in cooperative development

In 2013, orders were placed by more than 600 customers from almost 50 countries abroad.

12 Prospects

DWA's support to international education projects, e. g. for the training of wastewater treatment plant personnel, is an important contribution to environmental compatibility in emerging and developing countries.

Collaborative projects have been entered into with technical associations abroad in order to reinforce international partners, in order, for example, to internationalise standards and regulations.

DWA supports the international IFAT exhibition at home and abroad as a market opener.

13 Summary

Starting from initial, individual projects in the 1980s and 1990s, continuous activities related to products, projects and exhibitions in the international arena have developed. There continues to be demand from abroad for the translated standards and regulations and for other technical publications. DWA's technical expertise contributes to development cooperation projects for infrastructure development, for professional further education and training and other capacity development measures in south-east Europe and in the Middle East.

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Technical Sustainable Management in Water and Wastewater Treatment Plants

An Egyptian Experience

Adel Abotaleb, David Banner (Qena City-El Salheia, Egypt) and Ernst Doering (Cairo, Egypt)

TSM (Technical Safety Management) – is a system originally developed by the German Technical and Scientific Association for Gas and Water (DVGW) and the German Association for Water, Wastewater and Waste (DWA) to support German water utility companies in meeting their regulatory obligations with a particular emphasis on safety standards and regulations.

The TSM approach has been adopted, modified and customised 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 (WWMP).

In the Egyptian context, it was felt that a wider focus of TSM to include operation and maintenance, occupational health and safety, quality control/quality assurance and human resource management would provide more benefits to the overall operational sustainability of production and treatment. In order to reflect this change from the DWA standard the official name was changed to be *T*echnical *S*ustainable *M*anagement$_{Egypt}$ or TSM_{Egypt} for short. Another key strategic decision was to specifically target TSM_{Egypt} at the plant and facility level so that the plant management and staff become responsible for the improvement processes prior to the inspection and thus sustaining the requirements of TSM. This gives them greater influence over the processes and also they will not be held accountable for actions or inactions of others outside of their control. This is an important criterion for the formulation of appropriate requirements (questions) and guidelines during the preparation phase.

In the meantime, and after three years of preparation and implementation, TSM_{Egypt} has developed into a quality management programme for HCWW facilities that is supported by the DWA and is being applied in some 24 water and wastewater treatment plants so far. The focus of the TSM certification is to ensure that facilities comply with Egyptian laws, standards, codes and regulations and this compliance can be sustained throughout the validity period of the certificate, which is currently two years.

The TSM introduction started in 2008 with a comprehensive review of relevant Egyptian laws, regulations and codes, identification of key requirements within these articles that were specific to the operation, maintenance, safety, human resource, and quality control management of the facility. These requirements were then tested against the core principle of TSM_{Egypt} that any requirement and its associated actions could be carried out and sustained at facility level by the management and operation staff. At the heart of the TSM_{Egypt} process is/are

- a clear link to existing regulations, laws and codes – guiding principle
- guidelines to support the facility in meeting the requirements of the regulations and codes
- identification of evidence to demonstrate compliance – also contained in the guidelines
- systems and procedures to ensure sustainability.

TSM_{Egypt} inspection (documentation review) at El Obour WTP, Cairo

TSM$_{Egypt}$ site inspection of the Chlorine Contact tank at Hehia WWTP, Sharkia Governorate, Nile Delta

Concrete repair of the clarifier at Naga Hamady WTP, Qena, Upper Egypt

Improving work area safety – a major output of the TSM$_{Egypt}$, Dishna WTP, Qena, Upper Egypt

Improving safety of Alum Hoist, Dishna WTP, Qena, Upper Egypt

These requirements were then audited by expert groups and the DWA/DVGW to check whether they were relevant, achievable and could be sustained. Following revision and approvals they were published via a series of workshops and training events. Selected pilot plants then started the process of preparing themselves for inspection, typically over a 6–9 month period. DWA supported the inspection process by providing lead inspectors which then allowed for the training and authorization of local inspectors by on-the-job training and assessment. This resulted in initially five plants being awarded a TSM$_{Egypt}$ certificate and four inspectors being authorized to carry out inspections by the DWA. Up until this point TSM$_{Egypt}$ implementation, inspections and programme administration was carried out by members of the GIZ WWMP. Subsequently, the capacity of the HCWW was developed so that now the Holding Company is responsible for the entire TSM coordination and inspection process.

Full responsibility for TSM$_{Egypt}$ development, inspections and certification was transferred from GIZ/DWA to the HCWW. The transfer started with establishing a TSM$_{Egypt}$ Inspection Department within the HCWW, building their capacity, with the support of a CIM expert, to develop additional inspectors by training and attending inspections and certifying them through the DWA. A further three inspectors are now available to continue the programme with a planned 50 inspections to be carried out.

In the context of support to the TSM Inspection Department, HCWW: GIZ provided support to assist the TSM Department to obtain an ISO 17020 certificate. The Department is currently working to fulfill the requirements of the ISO certificate through exercising the necessary procedures and forms of TSM$_{Egypt}$ that complies with the ISO 17020. Meanwhile, the TSM Inspection Department has developed an implementation guide for TSM$_{Egypt}$ to clarify the processes and procedures for example; appointing new inspectors, the protocol for inspections, complaints against inspection decisions, etc. The TSM Inspection Department is now managing the entire process from receiving applications for inspections, arranging inspectors, monitoring inspections, results and issue of certification and most importantly follow up visits to plants that have previously received certificates to check standards are being maintained. A number of Inspectors meetings have been held to review and revise requirements and guidelines as a result of lessons learnt from carrying out inspections and to agree on the TSM$_{Egypt}$ guidelines. Currently, the total of 24 facilities has been awarded certificates made up of 14 water and 10 wastewater treatment plants.

The HCWW is now expanding the programme in two key areas: support to plants and facilities by the O&M Sector, HCWW to give guidance and technical support to plants preparing for their inspection and the expansion of TSM$_{Egypt}$ to cover new areas of operation such as oxidation ponds and water distribution networks.

During the first inspections it became clear that facility management and staff needed more support in understanding the requirements of TSM$_{Egypt}$, in many cases implementing new processes and procedures and to interpret the guidelines to ensure they could demonstrate compliance. A programme of workshops, training and knowledge transfer from inspectors to the O&M specialists within the O&M Sector, together with more involvement of staff from the affiliated companies appears to be having a positive effect with greater numbers of

Securing the Chlorine Drum Store, Dishna WTP, Qena, Upper Egypt

Guarding of pump/motor coupling, Dishna WTP, Qena, Upper Egypt

River Intake flooring replaced, Dishna WTP, Qena, Upper Egypt

companies applying for inspections, sending their staff on capacity building measures and training. WWMP adopted two different processes to facilitate transfer and exchange of experience and lessons learned among water and wastewater facilities, 1) design and implement TSM$_{Egypt}$ web portal which will be the platform for information exchange and cross fertilisation among TSM$_{Egypt}$ users, 2) implement a neighbourhood programme among water and wastewater facilities which is face to face discussions and hands on lessons learned knowledge transfer.

With the successful launch of TSM$_{Egypt}$ covering water and conventional wastewater treatment facilities there is scope to increase the coverage of processes that could be certified such as large oxidation pond wastewater treatment and water distribution networks. The more water and wastewater processes conform to Egyptian laws and regulations, greater aspiration and confidence is being built in the affiliated companies.

The WWMP, GIZ has carried out a feasibility check for using the existing requirements and guidelines for conventional wastewater treatment plants on large oxidation ponds, many of which are in operation or being constructed / commissioned in Middle and Upper Egypt. A successful TSM$_{Egypt}$ inspection was carried out in March 2012 at such a plant that demonstrated the existing requirements were flexible enough to accommodate different treatment technologies.

Water distribution networks are typically the most customer facing facility of a water company with daily interactions with customers, i.e. supply, pressure, leakage management, etc. it makes sense to expand TSM$_{Egypt}$ to cover this important aspect of operations by linking an existing TSM$_{Egypt}$ certified plant with a certified network. A draft set of network requirements and guidelines has been produced, revised and accepted through TSM inspectors meetings. The Qena Company for Water and Wastewater is in the process to apply for TSM$_{Egypt}$ inspection to the first water transmission and distribution network by the end of 2013.

Since 2008 the impact of TSM$_{Egypt}$ is measurable by proven compliance with regulations, laws and standards, demonstrated improvement in facility management processes and procedures and has been instrumental in building facility staff capacities, knowledge and skills. Significant improvement in staff morale and pride in their work has been noted together with the commitment of the HCWW to take over responsibility for the sustainability of the programme.

The most remarkable impact of this certification programme has been the change in the attitude of the staff of the certified facilities. This was clear during the follow up verification inspections of some of certified facilities with visible improvements sustained, such as cleanliness of facilities, high morale and adherence to management processes maintained.

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Step by step forward to the ideal sewage plant

The sewage plant Kaiserslautern (Germany) has succeeded in significantly reducing both, the sewage duty and the energy costs for the generation of process air for the aeration basins, in three steps. Thanks to the reduced sewage duty resulting from the basic changes of the aeration basins in the year 2008, the modification costs of 1.3 million EUR had been amortised after only three years. The replacement of the two existing turbo compressors against two new Aerzen rotary lobe compressors of series Delta Hybrid led to an additional energy saving of approx. 13 % of process air generation. Since then, the entire energy consumption per month could be reduced from approx. 250,000 to only 140,000 kWh. During field test, it is investigated whether the energy efficiency can still be improved any further by the replacement of additional turbo compressors – however, this time against the turbo blowers of the new Aerzen series 'AT Turbo Generation 5' provided with air bearings. Some first results represent another annual savings of energy, amounting to approx. 60,000 EUR and less maintenance costs of approx. 15,000 EUR per year.

At the sewage treatment plant Kaiserslautern (design capacity 210,000 PE, amount of wastewater approx. 60,000 m³/day) until 2008 the wastewater flew through the three rectangular cascade basins (total volume 22,500 m³) with upstream denitrification (fig. 1). Aeration was effected via fine bubble membrane aeration disks, 42 agitators in addition arranged for recirculation of the wastewater and six turbo compressors generated the process air in two groups:

- 3 turbo compressors for basins 1 and 2 (blow-in depth 4 m) High pressure 0.4 to 0.45 bar, max. delivery quantity each 10,000 Nm³/h,
- 3 turbo compressors for basin 3 (blow-in depth 6 m) High pressure 0.6 to 0.45 bar, max. delivery quantity each 5,000 Nm³/h.

The turbo compressors, each one of them a redundancy unit, were calculated in 1996 within a dimensioning of the sewage plant on occasion of the installation of the third cleaning stage. They worked with a constant pressure regulation and already demanded approx. 45 per cent of the entire energy requirement of the sewage plant. Measuring probes in the basin ensured the optimal air supply, pressure and quantity were controlled by the regulation organs in the compressors. Distribution to the basins was realised by iris diaphragms in the piping system. The originally used turbo compressors with slide- and antifriction bearing type of construction do not correspond anymore to the current state of the art for some time now. They work with upstream gearbox and a three-phase asynchronous motor with fixed speed. The plants are very big and cause extensive maintenance work.

Fig. 1: Aeration basins in Kaiserslautern

Step 1: Modification of aeration basins

In 2008 in the three aeration basins a completely new process and aeration concept was realised with an expenditure of 1.3 million EUR. Since then, the wastewater flows through the basins according to the principle of plug flow. Furthermore, the membrane aeration disks were replaced by fine bubble working membrane plate aerators made by Rudolf Messner Umwelttechnik. These measures improved the value for the parameter N_{Ges} from 13.0 to 10.4 mg/l of the purified wastewater led into the adjacent river Lauter. Solely by a considerable reduction of the energy costs the total investment of 1.3 million EUR would have paid back already after four years only. In addition, the amount of the sewage duty reduced durably, and beyond that the measure could be balanced with the sewage duty.

After modification of the basin the process air is not entered anymore by means of constant pressure, but depending on demand load and time-dependent. The ventilation is operated by a slide pressure control and a coordinated control technology. Due to these measures the energy requirement for the process

Fig. 2: Compressor hall

Fig. 3: Aerzen turbo compressor

air generation already reduced by approx. 40 per cent, due to the additionally no longer necessary 42 agitators even to approx. 58 per cent. As a consequence, the existing turbo compressors, especially at the lower performance limit, were dimensioned considerably too large, so that costly electrical energy was wasted. Therefore, first of all, they determined new required volumes and performed additional practical tests. They even considered the deconstruction of the turbo compressors to smaller capacities. Finally, they wanted to replace two turbo compressors by smaller positive displacement blowers, which should work in combination.

Step 2: Two new rotary lobe compressors

"After having contacted several bidders, in early 2010 we exchanged two old turbo compressors, but not against conventional positive displacement blowers, however, against two Aerzen rotary lobe compressors, of the at that time new Delta Hybrid series, as they convinced us by their technical data, their low energy requirement and very positive references. Aerzen units have already been well-known to us, as they have already worked in several sewage plants, which are operated via a subsidiary company", explains plant manager Joachim Steidel. (Fig. 2 shows the compressor hall, fig. 3 an Aerzen compressor) The oilfree compressing Delta Hybrid units are an ideal combination of the advantages of positive displacement blowers and screw compressors. Lower pressure systems with an innovative twisted piston profile tend to use blowers, whereas higher pressure systems with a special 3+4-screw profile tend toward the screw compressor. They are convincing by a considerably improved energy efficiency and offer energy savings up to 15 per cent, low maintenance and service costs, high reliability and a robust bearing design (service life 60,000 operating hours). In October 2010 the following packaged units were installed:

- for basins 1 and 2 (pressure range 0.4 to 0.45 bar)
  1 Delta Hybrid packaged unit, type D75L (maximum capacity 4,100 Nm^3/h),
- for basin 3 (pressure range 0.6 bar)
  1 Delta Hybrid packaged unit, type D62S (maximum capacity 3,001 Nm^3/h).

In the assigned basins both units covered the base and low load requirement, in case of higher requirement the available turbo compressor started. Due to this exchange of two fifteen years old turbo compressors against two Aerzen Delta Hybrid rotary lobe compressors Delta Hybrid the energy expenditure for generation of the activation air immediately reduced by 13 per cent every year.

Step 3: New turbo blower

An intensive examination of the frequencies of required quantities in basins 1 and 2 showed, that the exchange of the large turbo compressors used (delivery volume 10,000 Nm^3/h) against a unit meeting the demands will lead to further energy savings. Therefore, at the end of 2012 they decided for a field test, for which Aerzener Maschinenfabrik supplied a turbo blower of the new 'AT-turbo Generation 5' series. This new series had been introduced for the first time at the IFAT 2012. This unit (delivery volume 6,000 Nm^3/h) covered the most frequent operational range between 5,000 and 6,000 Nm^3/h on its own. For low-load operation below 4,100 Nm^3/h they used the Aerzen rotary lobe compressor series Delta Hybrid which had already been installed in 2010. In case of a requirement of more than 6,000 Nm^3/h both units work synchronously. This field test is to provide a reply to the following question:

- Can an Aerzen 'AT-turbo Generation 5' in combination with an Aerzen rotary lobe compressor series Delta Hybrid further improve the energy efficiency of the process air generation of the sewage plant?

Aerzener Maschinenfabrik has further developed the technology of the speed-controlled turbo blowers with air bearings to a new unit concept "Generation 5". This new concept had been inspired by the proven primary products Delta Blower positive displacement blowers and Delta Hybrid rotary lobe compressors with their modular system and the various customer advantages. The new turbo blowers AT-Turbo Generation 5 are available in the following performance ranges:

- Volume flows:17 to 220 m^3/min (1,000 to 13,200 m^3/h)

- Pressure range:400–1,000 mbar, higher pressures upon request

The new AT-turbo blowers "Generation 5" distinguish themselves by a further improvement of energy efficiency, low maintenance and service costs, high reliability and longevity by absolutely oil-free, contactless and vibrationfree air foil bearings. They work very quiet, can be installed space saving by means of side-by-side installation and are very operator friendly due to the integrated touch-screen control system. On these units, for the first time, the warm exhaust air can be blown off via a special flange. This "intelligent" side effect means for the operator: cool working spaces, no unnecessary warming of the aeration basins, and free exhaust heat if needed.

Ideal process air generators for compound systems

With these new turbo blowers series 'AT-turbo Generation 5' Aerzener Maschinenfabrik has realised the production of process air for biologically working sewage plants offering the highest possible energy efficiency and security of supply. As a rule the process air requirement of a sewage plant can only be realised by a combination of various machine types with various capacities, which can be defined as ideal base and peak load units due to their constructive features and performance ranges. The physical advantages of turbo machinery (high efficiency of the design point) can be perfectly combined with the advantages of rotary piston machines (high controllability and the good efficiency, also in part load operation). Here, the units of the new controllable series AT turbo Generation 5 prove the ideal base load generators. As optimal generators of peak and low load requirement Aerzen supplies the controllable positive displacement blowers series Delta Blower and the controllable rotary lobe compressors series Delta Hybrid.

Additional energy savings of approx. 60,000 EUR every year

"It is a fact, that the energy efficiency of the process air generation is continuously optimised", explained sewage plant manager Thorsten Jung in January 2014 and referred to the already available data of the field test and to calculations on the basis of the data of the combination of Aerzen units presently used for basins 1 and 2. The two Aerzen Delta Hybrid rotary lobe compressors, which are available since 2010 and according to Joachim Steidel and Thorsten Jung have proved successfully up to now, are kept available for all three basins as conjointly working redundancy units. But they are also planning to use an additional Delta Hybrid unit in basins 1 and 2 for covering the low load requirement. Based on the current knowledge the planned concept with the three new turbo blowers and the two Delta Hybrid rotary lobe compressors available since 2010 could once again considerably improve the energy balance of the process air generation by means of energy savings of approx. 60,000 EUR every year. In addition, due to the operation of exclusively new units the maintenance costs will reduce by approx. 15,000 EUR. Therefore, the operators expect a payback period of at most five years.

In the meantime, further sewage treatment plant operators are interested in the new concept realised in Kaiserslautern and the relevant good experiences. As successful service provider Wasser-Versorgung-Energie GmbH (WVE GmbH) Kaiserslautern, a subsidiary company of the municipality of Kaiserslautern, based on their own experiences, offer to other companies active assistance for all questions of water supply and wastewater disposal. The services of WVE include the competent advice concerning optimal process air generation, the optimal entrapped process air up to complete solutions as for example the conversion of aeration basins to pipe /plug flow. On request WVE, as a general contractor, arranges for the modification of sewage plants and guarantees for energy saving and discharge values. Basis of this knowledge is extensive data collection and intensive evaluation of the actual state for determining the optimal packaged unit for each application. In general, the combined operation of the Aerzen turbo blowers and rotary lobe compressors clearly proved, that the combination of both machine technologies can improve the energy efficiency of the process air generation in a sewage plant considerably.

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Products and Services

Tested long-term performance of fine-bubble diffusers

A current scientific study from University of California, Los Angeles confirms the efficiency of the aeration technology designed and manufactured by Aquaconsult in Austria.

A team of experts lead by Prof. *Michael K. Stenstrom* from the University of California, Los Angeles (UCLA) studied the performance of Aerostrip®-strip shaped fine-bubble diffusers. They were installed in a 100,000 PE sewage treatment plant in Bremerton (USA). The unique aspect was that the totals of 280 aerators with a size of 300 × 15 cm placed on the basin floor have already been operating continuously for more than eleven years. The studies are a part of a paper on the efficiency of different aeration systems which have been published in December 2012.

The result for the 11-year old fine bubble diffuser system with a minimal sludge age (from one to six days) they function better than all previously tested fine bubble diffusing systems with a comparable application time, and way better than many new other "classical" systems. Evaluation of oxygen transfer efficiency via off-gas testing was performed to evaluate the performance. During continuous operation, a collecting hood is placed on the water surface. Analysis of the oxygen percentage in the collected gas allows the scientist to draw conclusions about the operation and efficiency of aeration system. The oxygen yield in the waste water was 3.3 %/m blow in depth, with an α value of 0.5.

In pure water, an average yield of approx. 6.6 % per metre of blowing depth was achieved. After cleaning with a simple high-pressure water blast, the bubble pattern of the aerators could be considerably improved and the oxygen usage could be increased to 7.3 %/m. Those were only 10% less reduction in oxygen transfer efficiency compared with brand-new Aerostrip diffusers.

www.aquaconsult.at KA

Kemira DesinFix® wins a WEX Global Award 2014

Kemira DesinFix, the halogen-free disinfection concept for water and wastewater streams, has won the WEX Global Award in the category "Innovation in Water and/or Wastewater Management" during the WEX Global Summit 2014 in Madrid, Spain. WEX, short for Water and Energy Exchange, presents the award to recognize innovation in the realization of sustainable water and/or waste water management. It honours projects or programs of water management which display excellence in developments related to sustainable water management in an urban environment.

The prize was presented to *Patricia Aubeuf-Prieur*, Kemira's Project manager for DesinFix, by *Miguel Angel Sanz*, Director for Development and Innovation at Degrémont.

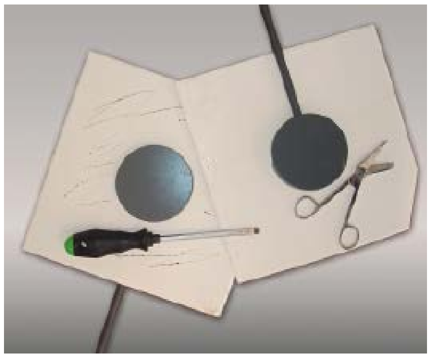
DesinFix is an environmentally-friendly disinfection system that is suitable for all types of wastewater, raw water and storm water flows. The halogen-free technology kills sustainably all bacteria, fungi and viruses, and is at the same time insensitive to high contents of suspended solids or iron concentrations in the water. Furthermore, the compact equipment allows quick installation at a comparatively low investment.

The WEX organization arranges worldwide high-profile conferences in the areas of water and energy. The annual highlight is the "WEX Global Summit", which brings together the world's leading organizations in the water sector.

www.kemira.com KA

Self-Healing Membrane

When talking about the operation of waste water treatment plants using MBR technology, factors like energy savings,



reduction of the chemical demand or minimization of the total costs of a plant are of major interest. Besides these, one criterion is becoming increasingly important. The membranes built into submerged modules and installed in a wastewater treatment plant have to be of the highest quality in order to ensure, amongst others, the compliance with international water standards when looking at effluent quality and turbidity.

A damaged membrane is one of the worst things that can happen to an operator of a waste water treatment plant and respectively to the manufacturer of the membrane module. Screw drivers or other tools falling into the filtration chamber of a plant, damaging the membranes severely, are not a rare event.

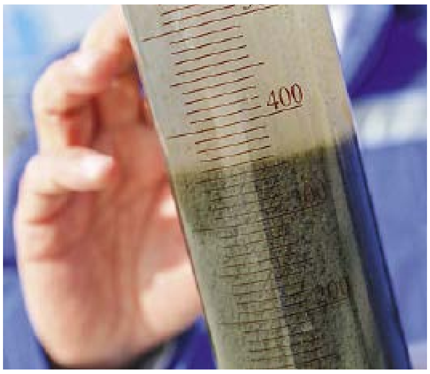
Microdyn-Nadir is proud to announce that the BIO-CEL® sheet which represents the core part of the BIO-CEL® MBR module by Microdyn-Nadir has a self-healing mechanism. Due to its sandwich-like and self-supporting structure the membrane “heals” itself even though it might be damaged considerably (deep scratches, cut edge etc.) and closes any scratch or cut immediately.

Several tests have proven that, even under worst case conditions, such as very low MLSS (mixed liquids suspended solids) concentrations and immense damages of the sheet, the BIO-CEL® module offers turbidity values which are compliant with existing international regulations for water reuse.

www.microdyn-nadir.com KA

New cationic powder flocculants

BASF has globally launched a new ultra-high molecular weight cationic powder flocculant range with Zetag® *ULTRA* for solid/liquid separation in industrial and municipal waste water treatment. Zetag® *ULTRA* has been developed combining BASF’s long-standing application expertise in water solutions with its extensive polymer research know-how, focusing on specific customer requirements while considering environmental aspects. Zetag® *ULTRA* complements the existing BASF flocculant range to better serve future equipment trends in the dewatering market.



Because of its effective bridging capabilities, Zetag® *ULTRA* shows advanced dewatering performance. It offers strong floc integrity to withstand high shear forces which makes it especially effective for the use in centrifuge applications as well as for dissolved air flotation.

“Today industrial and municipal water treatment plants are challenged to achieve maximum performance under increasing cost pressure.” says Marcus Fuest, Global Industry Marketing Water Solutions. “Zetag® *ULTRA* has proven its excellent performance in a variety of extensive plant trials worldwide. Our customers report that cake solids of dewatered sludge increased in average by 15%. Other customer cases show a significant dose saving of up to 20%. Furthermore the centrate has an improved capture rate. Zetag® *ULTRA* is the ultimate fit to answer our customers’ needs.”

The new high performing flocculants allow waste water treatment plants operating more efficiently and effectively. The molecular architecture of Zetag® *ULTRA* offers customers a clear cost advantage through operational cost savings. The achieved higher cake solids are environmentally beneficial as less energy is required for transportation, disposal and incineration, which has a positive impact on the carbon footprint of the treatment facility.

www.watersolutions.basf.com KA

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