International Special Edition in English

International Special Edition, May 2012

KA Korrespondenz Abwasser · Abfall

International Special Edition 2012

www.dwa.de/KA

Trickling Filters for Hot Climatic Zones

Iranian Wastewater Sector

Water Reuse

PE Sewer Pipes

Pricing Policies

Concerted Action – Croatia

Training in Bangladesh

Cost-Benefit Analysis

Young Water Professionals

Capacity Development

DWA

CD-ROM

German DWA Rules and Standards

English Version

Edition April 2012

The DWA Set of Rules and Standards consists of standards and advisory leaflets. Standards contain the generally accepted rules of technology. Advisory leaflets describe the state of the art. The CD-ROM additionally contains DWA-Topics which present elementary results from the honorary work of the DWA specialists groups. Furthermore, you will find selected brochures for your information and public relations.

Exemplary issues

- Drain and Sewer Systems (Hydraulic Calculations, Pipe Jacking, Stormwater, Inspection, Operating Instructions, ...)
- Municipal Wastewater Treatment (Activated Sludge, Biologically Treated Wastewater, Emission Reduction, ...)
- Waste and Sewage Sludge (Biogas, Sludge Thickening, Biological Stabilisation, ...)
- Industrial Wastewater (Water Reuse, Wastewater Analysis, ...)
- Hydraulic Engineering (Fish protection, Tailing Impoundment, ...)
- Economics (Quality Management Systems, Benchmarking, Cost Structures, ...)
- PR (Policy Memorandum, numerous brochures, ...)

DWA-Publications are viewed as the basis for planning, construction, improving and operation of plants in water, wastewater and waste management, as well as in soil conservation.

- **German DWA Rules and Standards – English Version on CD-ROM**
  English translations of significant publications of the DWA Set of Rules and Standards
  56 Standards and Advisory Leaflets, 6 Topics and various brochures in pdf format **€ 690,00*
- **Update 2012**
  Only for customers of the March 2009 Version
  Edition April 2012 **€ 90,00*

DWA Corporate Members get a reduction of 20 %.
The prices include the VAT plus shipping.
Prices are subject to alteration and no responsibility is accepted for errors.

Fax: +49 2242 872-100

Yes, **I would like to order**
..... CD-ROM German DWA Rules and Standards
..... CD-ROM Update

DWA
German Association for Water, Wastewater and Waste
Customer Service
Theodor-Heuss-Allee 17
53773 Hennef • Germany

Sender

Surname/First name

Firm/Authority

Street

Town/Country/Postcode

Number of Membership

Date/Signature

☐ Yes, I wish to receive further information of DWA/GFA/EWA by E-mail.

4/12

DWA · Theodor-Heuss-Allee 17 · 53773 Hennef · Germany · Tel.: +49 2242 872-333 · E-Mail: info@dwa.de · Internet: www.dwa.de

Contents

Front cover: Wastewater treatment plant of BASF – The Chemical Company in Ludwigshafen, Germany (photo: BASF SE)

KA Korrespondenz Abwasser, Abfall

International Edition 2012

Journal of the German Association for Water Management, Wastewater and Waste (DWA)

Publisher:
GFA
Theodor-Heuss-Allee 17, 53773 Hennef, Germany
P. O. Box 11 65, 53758 Hennef, Germany
phone (+49 22 42) 872-0, fax (+49 22 42) 872-151
web: www.gfa-ka.de, http://en.dwa.de/journals.html

Editor:
Dr. Frank Bringewski
phone (+49 22 42) 872-190
e-mail: bringewski@dwa.de

Advertising:
Andrea Vogel, Christian Lange
phone (+49 22 42) 872-129
e-mail: vogel@dwa.de

Editorial office:
Annette Wollny
phone (+49 22 42) 872-138
e-mail: wollny@dwa.de

Pre-press and printing:
Bonner Universitäts-Buchdruckerei
Justus-von-Liebig-Straße 6, 53121 Bonn, Germany

Water – No Longer a National Issue

Environmental and water issues are attracting increasing attention at an international level. Water bodies, rivers and streams do not stop at political borders. If the world population increases as projected, the topical subject “environment” will gain in importance, especially in countries, where the protection of the environment does not play an essential role yet. In this respect, water is a special issue, because it is the foundation and source of life as we know it on planet earth. A growing population implies more waste, which has to be disposed of in benign ways. Solid waste and wastewater alike have more to be considered and used as a source of raw materials. The catchphrase that is frequently used is “urban mining”.

Germany is in the lucky position that it has sufficient water for its population, for agriculture and industry. German environmental and water technology are widely respected and being hold in high esteem throughout the world. The German water sector is at a high level with sophisticated techniques and regarding the quality of operational management. The personnel is well trained.

All this is sufficient reason for the German water industry and municipal operations to offer its services and help at a more international level. This holds true also for the German Association for Water Management, Wastewater and Waste (DWA). In recent years, DWA is increasingly engaging in international activities. The organization with 14,000 members in Germany is cooperating with UN Water and development aid agencies, for instance. DWA thus offers the expertise of its members in a variety of international projects. A large part of this is about training and “capacity development” in the water sector. This is also a matter of charity and altruism, although it cannot be denied that there may also be commercial aspects.

One component of this commitment is that DWA and its commercial branch GFA are now publishing an international issue of their in the German-speaking world highly respected technical and scientific journals. Three of the articles included have been published in the previous year in German, but they deserve a more international attention. *Pressinotti* et al. report on “The Trickling Filter Process for Hot Climatic Zones”. *Mohajeri* addresses a highly political issue: “Modernization of the Iranian Wastewater Sector and Cooperation Opportunities for German Companies”. *Fuhrmann* et al. raise questions on water reuse – and hopefully give useful answers. This subject is of particular importance in many countries of the world, especially those with arid climate, or in plain words: water shortage. More practical is the article of *Eckert* on “Polyethylene Sewer Piping Systems”. A prerequisite for many activities are financial funding and monitoring of success. *Wahliß*, working with the government of the German state of Bavaria, in his article has a focus on “Pricing Policies for Sustainable Water Services”, while *Schmidtke* contributes an article on “Cost-Benefit Analysis – User’s Project Appraisal Manual”. All this is rounded off by articles on training for wastewater operators in Bangladesh, on capacity development – international

water training and on a “Young Water Professionals’ Programme” that is conducted periodically by DWA which enables young water experts from outside Germany to take part in an extended tour through the German water sector.

We do our very best to help people in other countries to deal with their water matters or problems. The present issue, the international edition in English of our journal, the first one in English after years, is to help a little bit in the transfer of knowledge. I do hope that you enjoy it and find something useful in it.

Bauass. Dipl.-Ing. Otto Schaaf
President of DWA

		Title	Euro
☐ Electronic Media/ Software	***New!***	**Special Offer IFAT ENTSORGA 2012 – offer applies up to 31 August 2012** **German DWA Rules and Standards (CD-ROM) – Update-price for all customers. We give you the basic version for FREE!** English translations of significant DWA Rules and Standards 56 Standards / Advisory Leaflets, 6 Topics and various brochures at PDF format (single user), Edition: April 2012	~~690,00~~ *) 90,00 *)
☐ Drain and Sewer Systems Software	***New!***	**Statics-Expert / Structural Calculation of Buried Pipes** **Standard-Edition** ☐ Module Open-Cut Method of Construction (ATV-DVWK-A 127) ☐ Module Pipe Jacking (DWA-A 161) ☐ Module DWA Complete (ATV-DVWK-A 127 and DWA-A 161) **Profi-Edition** ☐ Module Open-Cut Method of Construction (ATV-DVWK-A 127) ☐ Module Pipe Jacking (DWA-A 161) ☐ Module DWA Complete (ATV-DVWK-A 127 and DWA-A 161)	 1.337,50 *) 1.872,50 *) 2.407,50 *) 1.872,50 *) 2.407,50 *) 2.942,50 *)
☐ Drain and Sewer Systems Software	***New!***	**Hydraulics-Expert** Hydraulic Calculations of Sewer and Special Structures ☐ Version Standard (DWA-A 110) ☐ Version Professional (DWA-A 110, DWA-A 111, DWA-A 112) ☐ Upgrade Standard to Professional	 195,00 *) 750,00 *) 555,00 *)
☐ Drain and Sewer Systems	***New!***	**DIN EN 12889/DWA-A 125E** **Trenchless Construction and Testing of Drains and Sewers/Pipe Jacking and Related Techniques** May 2009, 92 pages, DIN A4, ISBN 978-3-942964-37-1	98,00 *)
☐ Drain and Sewer Systems	***New!***	**DIN EN 1610/DWA-A 139E** **Construction and Testing of Drains and Sewers** January 2010, 104 pages, DIN A4, ISBN 978-3-941897-67-0	107,00 *)
☐ Economics	***New!***	**Advisory Leaflet DWA-M 803E** **Cost Structures in Wastewater Engineering** November 2006, 71 pages, DIN A4, ISBN 978-3-941089-74-7	80,00 *)
☐ Economics	***New!***	**Advisory Leaflet DWA-M 1100E** **Benchmarking in Water Supply and Wastewater Disposal** March 2008, 19 pages, DIN A4, ISBN 978-3-941897-20-5	29,50 *)
☐ Economics	***New!***	**Dynamic Cost Comparison Calculations for selecting least-cost projects in Water Supply and Wastewater Disposal** DCCC – Appraisal Manual for Project Designers December 2011, 133 pages, 23 figures, 23 tables, DIN A4, ISBN 978-3-941897-05-2	58,00 *)

*) DWA-Corporate Members receive a 20 % discount.

All publications are available as E-Books in PDF format at the same price.
More software and demos on our website www.dwa.de/software

Customer Service
Tel.: +49 2242 872-333
Fax: +49 2242 872-100

The Trickling Filter Process for Hot Climatic Zones

Fabio Chui Pressinotti (Darmstadt, Germany), Jörg Krampe (Adelaide, Australia) and Heidrun Steinmetz (Stuttgart, Germany)

Abstract

The main advantages of trickling filters are their relatively low energy demand and only a few wearing parts. Apart from that, they do not require highly qualified staff and make a robust and cost-effective wastewater treatment possible. For these reasons, this technology can be especially interesting for developing countries with a growing need for wastewater treatment. Since many of these countries are located in hot climate zones and current dimensioning standards are based on experience from regions in temperate climate zones, a direct application of these standards can lead to incorrect dimensioning results. Therefore, and in particular with regard to the export of German technology, the current dimensioning standards must be reviewed to check whether they are also suitable for other climate zones. In this context, a semi-scale trickling filter was operated under high air and wastewater temperatures within a climate chamber on the premises of the WWTP of the University of Stuttgart. Two packing materials were investigated: lava slag and plastic medium (cross-flow). Carbon removal and nitrification were evaluated. The results show a large potenzial for the use of trickling filter technology in hot climate zones. In these regions, higher organic loadings than the ones recommended in ATV-DVWK-A 281 can be applied. For carbon elimination only with lava slag trickling filters, a volumetric load of 1.0 kg BOD_5/(m^3·d) is possible at a wastewater temperature of 25 °C, which means a saving on volume of 60 % in comparison with the specifications in worksheet ATV-DVWK-A 281. Even higher volumetric loads can be set with plastic trickling filters. A stable partial nitrification can also still be achieved with high volumetric loads.

Key words: wastewater treatment, municipal, trickling filter process, design, temperature, high, pilot plant, semi-scale, packing, lava, plastics, carbon, nitrogen, removal, nitrification, ATV-DVWK-A 281

1 Introduction: Influencing factors and interaction with the temperature

In the trickling filter method, the pre-cleaned wastewater is distributed by a rotary sprinkler in the upper region of the trickling filter and from there it seeps through the pores in the packing material, which is overgrown with a biofilm. Over the course of the flow section, the nutrients are transported in particular by diffusion processes into the biofilm and converted. Oxygen is supplied by the transport of atmospheric oxygen via the water film in the biofilm. The oxygen concentration in the air is influenced by natural convection processes. The temperature difference between the inside and outside air causes a stack effect and thus a change of air in the trickling filter. Blockages caused, for example, by excessive growth of the biofilm must be avoided, however, so that the air can freely circulate. Blockages can lead to a lack of oxygen and to the formation of anaerobic biofilms. The consequences of this are diminished cleaning performance and the production of unpleasant odours. Hydraulic shear forces are required in order to control the thickness of the biofilm. These can be controlled in the trickling filter by the rinsing force (dosing quantity per revolution of a rotary sprinkler arm). This can be adjusted by means of the structural design of the rotary sprinkler, the speed of rotation and the hydraulic feeding (surface feeding). The variation of the hydraulic feeding is usually achieved by recirculation of the discharge, which additionally limits the speed of growth of the bacteria by diluting the inlet. The recirculation also increases the surface feeding and is therefore important for a homogeneous distribution of the wastewater and an adequate degree of utilisation of the packing material surface, but on the other hand it also increases the energy requirement of the trickling filter method.

Although the procedural principle and the operation of a trickling filter are simple, the physical and biological interactions between the various influencing factors and the temperature are complex, so that the influence of the temperature on the cleaning performance of the trickling filter has not been absolutely clarified so far. Numerous data are given in technical literature with regard to the influence of the temperature. However, these are incomplete and sometimes contradictory (for example [1-4]).

Apart from the biological activities of the microorganisms, other influencing factors are affected by the temperature conditions, such as the mass transfer processes (mainly diffusion), the thickness of the biofilm and the oxygen supply. Some of these factors can even have detrimental effects on the cleaning process.

The oxygen supply, for example, depends on the transfer of oxygen from the air to water to the biofilm. The concentration of oxygen in the air is linked among other things to the exchange of air in the trickling filter due to the aforementioned temperature-dependent stack effect. Since the oxygen transport takes place primarily via diffusion, the oxygen concentration is strongly linked with concentration gradients. The wastewater temperature is a limiting factor for the saturation concentration of the oxygen in the wastewater. The solubility of oxygen in water decreases as the temperature increases. Conversely, the oxygen diffusion coefficient (and also that of the other substrates) increases with higher wastewater temperature. Other influencing factors such as the flow conditions and the biofilm structure also influence the oxygen transfer [5].

Gebert [1] showed that the thickness of the biofilm in the trickling filter is influenced by the interaction between the temperatures of the air and the wastewater. When winter begins the thickness of the biofilm increases rapidly, reaching a maximum in spring. Subsequently, sludge repulsion occurs. The biofilm remains thin in the warm months and in autumn it can become a little thicker. In winter a considerably thicker biofilm is found. The separation appears to be triggered by the change in the relationship between the wastewater temperature and the air temperature. The biofilm only starts to separate after the air temperatures rise above those of the wastewater, so that the biofilm warms up before separation. Analogously, the strong growth of the biofilm only begins after the air temperatures fall below those of the wastewater, so that the biofilm cools down before growth. If the thick biofilm in winter is well aerated, the negative effects of the low temperatures can be compensated by the increased quantity of biomass and the associated increase in the trickling time.

Beyond that, our own investigations suggest that the increase in the temperature does not cause a homogeneous increase in the conversion speeds in the vertical profile of the trickling filter. Since the trickling filter is a plug flow reactor, the concentrations in the vertical profile decrease from top to bottom. As the wastewater temperature increases, the conversion speeds in upper region of the trickling filter also increase. Due to the faster decrease in the concentration, the conversion speeds in the lower region of the trickling filter can be strongly limited by concentration, so that in the case of low volumetric loads in particular, the conversion speeds in the lower region can be slower, despite the increase in temperature.

For the reasons described above the influence of the temperature on the cleaning performance of trickling filter systems is understandably difficult to quantify. Therefore, the dimensioning approaches employed so far do not take into account the influence of temperature or do not take it sufficiently into account (for example [6-9]). This may lead to erroneous dimensioning results in hot climates when using empirical dimensioning values determined in moderate climates.

2 Semi-scale trickling filters and test execution

In order to investigate the influence of high temperatures on the trickling filter method, a semi-scale trickling filter was erected in the test hall of the teaching and research wastewa-

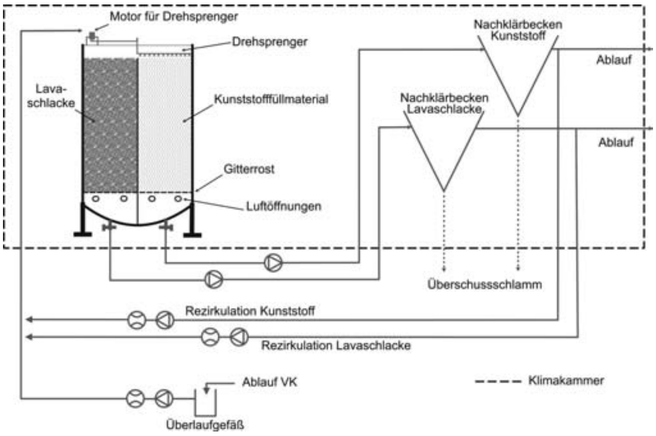


Fig. 1: Block diagram of the semi-scale trickling filter

ter treatment plant at the university of Stuttgart (WWTP) and enclosed in a climatic chamber (figure 1). The air temperature was set by means of air conditioning equipment installed for this purpose. It was possible to control the wastewater temperature by means of heat exchangers.

The trickling filter had a volume of 18.4 m³, a diameter of 2.5 m, and a filling height of 3.9 m and was divided in the middle by a vertical PVC partitioning wall. One side was filled with lava slag, while the other side was filled with a plastic packing material (Table 1). This allowed a direct comparison of the two packing materials under the same wastewater and temperature conditions.

For the aeration of the trickling filter, 20 air tubes with an internal diameter of 5 cm were installed in the hollow space under the grating (ten for each packing material). The distributor consisted of a motor-driven rotary sprinkler arm.

The trickling filter was fed with pre-cleaned wastewater from the WWTP. The feed pump was controlled analogously to the load curve of the WWTP. In order to enable the separate recirculation of the discharge from both packing materials, a secondary sedimentation tank was placed downstream and a recirculating pump was used for each packing material. The secondary sedimentation tanks were located inside the climatic chamber together with the trickling filter in order to avoid temperature-related density flows in the secondary sedimentation tanks. Position sensors installed on the rotary sprinkler controlled the recirculating pumps such that the packing material was fed only with the respective recirculation discharges. It was therefore possible to examine the two packing materials completely independently of each other.

The trickling filter was operated for a total of approx. ten months. The wastewater temperature and the air temperature were kept constant at 25 °C and 30 °C respectively. In order to investigate the influence of the volumetric load on the cleaning performance of the trickling filter, the tests were divided into six different phases of approx. six weeks each and the BOD_5 volumetric load was gradually increased from phase to phase (Table 2). The rinsing force, surface feed and recirculation ratio were adjusted in accordance with the specifications of the worksheet ATV-DVWK-A 281 [6].

The feed samples were taken from the discharge of the primary sedimentation of the teaching and research wastewater treatment plant of the University of Stuttgart and the discharge samples from the respective discharges of the semi-scale secondary sedimentation by means of automatic sample takers. For technical reasons, 24-hour time-proportional mixed samples were initially taken; this was later changed to 24-hour flow-proportional mixed samples. As a result of the flat load curve of the feed and the adjustment of the feed pumps, no large differences were found between the two types of sample.

As already explained, the dimensioning values in worksheet ATV-DVWK-A 281 were derived from empirical values and performance curves of trickling filters under moderate wastewater temperature conditions. Against this background a comparable approach was selected for the investigations at higher temperatures. Using this method it was possible to place our own results from semi-scale tests against those from large-scale industrial trickling filters. Ultimately it is possible in this way to expand the area of validity of the current dimensioning approach according to ATV-DVWK-A 281 at higher temperatures.

Packing material	Origin	Structure	Specific surface area	Void proportion
Plastic	2H-Kunststoff GmbH (type TKP 619)	Crossflow (60°)	152 m²/m³	> 95 %
Lava slag	Wastewater treatment plant, Steinbronn	Aleatoric, granulation 40-70 mm	approx. 90 m²/m³	approx. 50 %

Table 1: Packing material properties of the semi-scale trickling filter

Phase	TF feed (without recirculation)				Lava slag			Plastic		
	$B_{R,BOD5}$	$B_{R,TKN}$	C_{BOD5}	C_{TKN}	q_A	RR	RF	q_A	RR	RF
	kg/(m³·d)	kg/(m³·d)	mg/l	mg/l	m/h	%	mm	m/h	%	mm
I	0,15	0,042	139	40	0,7	280	8	0,7	310	9
II	0,22	0,072	113	34	0,6	80	6	0,6	90	6
III	0,43	0,120	168	44	0,8	90	7	0,8	90	7
IV	0,62	0,149	188	44	1,0	90	9	1,0	90	9
V	0,77	0,196	172	44	1,3	70	21	1,3	70	20
VI	1,02	0,260	193	50	0,9	0	29	0,9	0	29

q_A = Surface feed, RR = Recirculation ratio, RF = Rinsing force

Table 2: Operating parameters of the trickling filter (mean values)

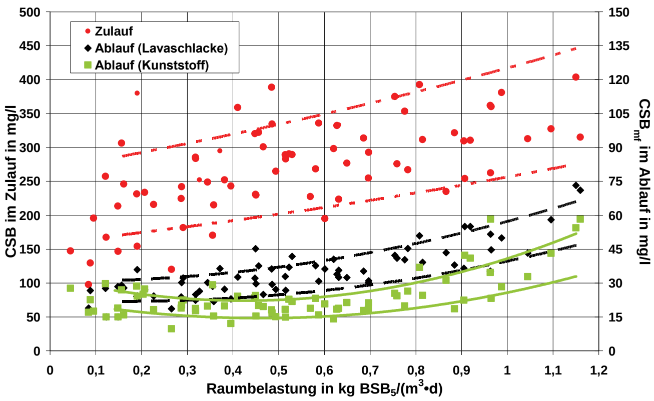


Fig. 2: COD$_{hom}$ in the feed and COD$_{mf}$ in the discharge of the trickling filter in relation to the BOD$_5$ volumetric load

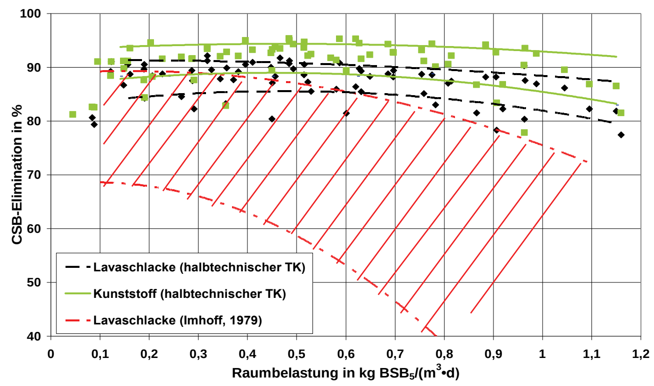


Fig. 3: COD elimination in relation to the BOD$_5$ volumetric load of the semi-scale trickling filter with lava slag at a wastewater temperature of 25 °C and of the boulder-filled trickling filters of the Ruhr Association with moderate wastewater temperatures.

3 Illustration and evaluation of the semi-scale test results.

Table 2 summarises the average set operating parameters for each phase. The increase in the BOD$_5$ volumetric load was achieved in particular by increasing the pumping capacity of the feed pump. In addition, the BOD$_5$ values in the feed were also increased during the tests. The influence of the increase in the BOD$_5$ values on the cleaning performance of the trickling filter over the course of the tests is taken into account together with the illustration of the results. The mean value of the BOD$_5$/TFN ratio for the complete test section was around 3.8.

In order to exclude the influence of the secondary sedimentation on the elimination performance, the discharge samples were filtered by membrane in order to determine the carbon elimination. Figure 2 shows the COD$_{hom}$ values in the feed and the COD$_{mf}$ values in the discharge in relation to the BOD$_5$ volumetric load. The COD elimination as a percentage ($(C_{CODhom,FEED} - C_{CODmf,DIS}) \cdot 100 / C_{CODhom,FEED}$) can be taken from figure 3.

In order to compare the determined COD elimination of the lava slag with the values from literature, the confidence region obtained is compared to the data from Imhoff [10] in figure 3. Imhoff's data correspond to the results from 44 trickling filter plants operated by the Ruhr Association, which are operated at moderate temperatures. Since the data from literature, which are related to the plastic packing material, differ strongly from one another on account of the various types of packing materials employed, the classification of the data is only possible with difficulty. Therefore, this was dispensed with.

The lowest COD$_{mf}$ discharge value was 15 mg/l for the lava slag and 10 mg/l for the plastic packing material. The maximum COD$_{mf}$ discharge value reached 78 mg/l for the lava slag and 53 mg/l for the plastic packing material. Since, as previously explained, the feed concentrations considerably increase as the volumetric load increases, the increase in the discharge values is partly attributable to the increased concentrations of the feed.

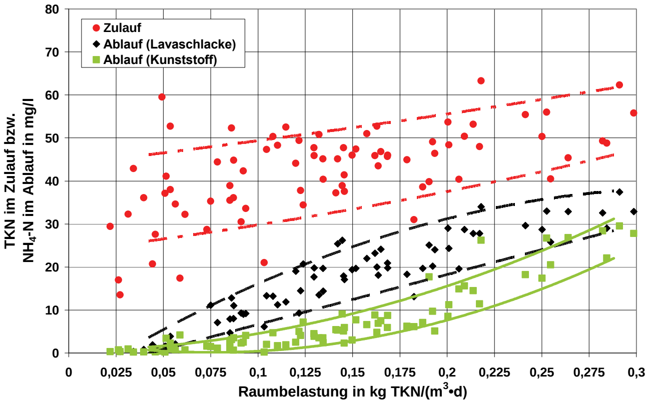


Fig. 4: TFN in the feed and NH_4-N in the discharge of the trickling filter in relation to the TFN volumetric load

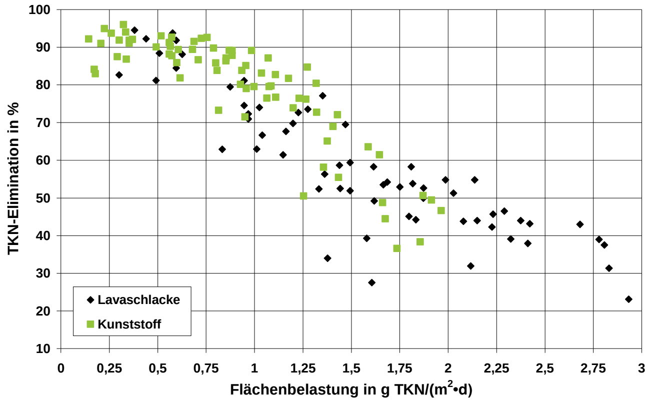


Fig. 6: TFN elimination of the trickling filter in relation to the TFN surface load

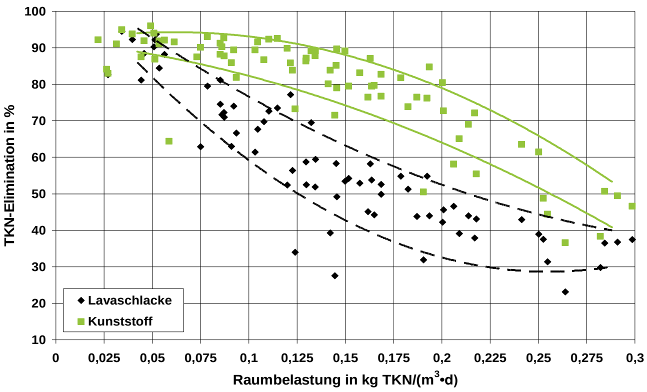


Fig. 5: TFN elimination of the trickling filter in relation to the TFN volumetric load

The confidence region of the discharge concentrations of the semi-scale lava slag trickling filter always lies approx. 3 % below that of the plastic packing material. Since this difference remains approximately constant regardless of the organic load, the higher cleaning performances of the plastic trickling filter cannot be attributed to its higher specific packing material surface area. Other properties of the plastic packing material such as, for example, its larger pores for the permeation of air as well as the flow conditions apparently also play an important part here.

The much smaller span of the confidence region of the semi-scale trickling filter in comparison to that from the study by Imhoff can be attributed to a comparatively more stable operation due to the strictly controlled boundary conditions in the climatic chamber. If the confidence regions of the COD elimination of the semi-scale lava slag trickling filter are compared with the data from Imhoff, it can be seen in the lower volumetric load range near the upper line of the confidence region that only a marginally higher COD elimination can be achieved with a wastewater temperature of 25 °C. This not an actual degradation performance, but instead can be attributed to the fact that membrane-filtered samples in the discharge of the secondary sedimentation were analysed in this study, whereas Imhoff evaluated discharge samples from the secondary sedimentation in the laboratory after a settling time of two hours.

According to the upper line of the confidence region for the lava slag, the maximum COD eliminations from both studies remain approximately constant up to approx. 0.3 kg BOD_5/(m³·d). Hence, it can be assumed that, in this range of the volumetric load, an increase in performance is not possible by increasing the temperature, or that a reduction in volume cannot be realised with regard to the current dimensioning approaches. As the volumetric load increases, the values from Imhoff lying within the confidence region decrease much faster. Therefore, an increase in performance as a result of increasing the wastewater temperature is only recorded at volumetric loads larger than 0.3 kg BOD_5/(m³·d). As the volumetric load increases, the distance between the two confidence regions continually increases, so that considerable potenzial exists to save volume at high temperatures.

Nitrification in trickling filters is usually assessed on the basis of the NH_4-N elimination. To this end, the NH_4-N elimination is defined either as the nitrate proportion in the discharge [NO_3-N_{DIS}/(NO_3-N_{DIS} + NH_4-N_{DIS})] or as the eliminated ammonia proportion of the feed [(NH_4-N_{FEED} – NH_4-$_{DIS}$)/NH_4-N_{FEED}]. The first approach can be erroneous, since the nitrate proportion eliminated by simultaneous denitrification is not taken into account. The second approach, conversely, does not take into account the additional NH_4-N freight generated in the trickling filter by ammonification. In order to minimise this error, the TFN elimination was selected here [(TFN_{FEED} – NH_4-N_{DIS} – $N_{org,DIS}$)/TFN_{FEED}). On the basis of the worksheet ATV-DVWK-A 131 [11], organic nitrogen in the discharge was assumed to be 2 mg/l. The NH_4-N discharge values and the TFN feed values were plotted against the TFN volumetric load in figure 4; the percentage TFN elimination was plotted against the TFN volumetric load in figure 5.

Since the feed concentrations also increase with increasing volumetric load over the course of the tests, the increase in the discharge values cannot be attributed to the increase in the volumetric load. It is not possible to separate the two effects. In the entire volumetric load range examined, higher TFN eliminations and lower NH_4-N discharge concentrations are found for plastic trickling filters. In order to check whether the higher performance of the plastic packing material can be attributed to its higher surface area, the percentage TFN elimination was plotted against the TFN surface load in figure 6. For the specific surface, 90 m²/m³ was assumed for the lava slag and 152 m²/m³ for the plastic packing material.

Good correlation between the two confidence regions can be seen in figure 6. The minimal deviations between the two

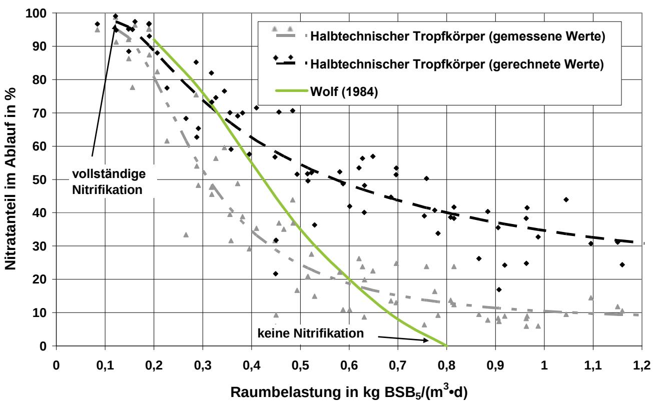


Fig. 7: Calculated and measured nitrate proportions [NO_3-N/(NO_3-N + NH_4-N)] in the discharge of the semi-scale lava slag trickling filter with a wastewater temperature of 25 °C and of boulder-filled trickling filters with moderate wastewater temperatures [4]

packing materials were attributed to operational aspects (biofilm thickness, trickling time, aeration).

Data for estimating the nitrification over a wide volumetric load range at moderate temperatures was determined by Wolf [4]. For this purpose he referred to the nitrate proportion [NO_3-N/(NO_3-N + NH_4-N)] in the discharge of the trickling filter as a guiding parameter for the nitrification. This gives rise to the problem that the reduction of the NO_3-N due to simultaneous denitrification is not taken into account. For this reason, the direct comparison of the nitrate proportions with Wolf's data is only conditionally possible. In order to circumvent this, the nitrogen quantities eliminated by nitrification were added to the measured NO_3-N discharge values of the semi-scale lava slag trickling filter. In doing so it was assumed that 1.5% of the COD freight in the feed is incorporated as nitrogen in the biomass and that there are 2 mg/l N_{org} in the discharge (NO_3-$N_{calculated}$ = NO_3-$N_{measured}$ + NO_3-$N_{denitrified}$ = $N_{total,feed}$ – incorporation – NH_4-N_{DIS} – 2 mg $N_{org,DIS}$/l). However, a direct comparison requires that Wolf's curve also be corrected with regard to the denitrified nitrogen proportion. Since the necessary data are not available, only a qualitative comparison can be performed with the available data. The nitrate proportions for trickling filters with moderate temperatures from Wolf, the nitrate proportions determined by calculation – taking into account the denitrified nitrogen for the semi-scale lava slag trickling filter – and the measured nitrate proportion for the semi-scale lava slag trickling filter are compared with one another in figure 7.

It can be seen that the curve with the measured nitrate proportions (without taking into account the denitrified nitrogen) at 25 °C lies for the most part below Wolf's curve in the volumetric load range examined. The curve that takes into account the denitrified nitrogen, however, mostly lies above Wolf's curve.

In the low volumetric load range [< approx. 0.3 kg BOD_5/(m^3·d)], Wolf's curve and the calculated curve of the semi-scale trickling filter lie close together. If Wolf's curve were to be corrected with regard to the denitrification, it could lie even higher than shown in figure 7. An improvement of the nitrification as a result of high temperatures is therefore not observed in this volumetric load range. According to Wolf's curve, nitrification does not take place at all in the high volumetric load range [> approx. 0.8 kg BOD_5/(m^3·d)]. In comparison with the other two curves shown, with a wastewater temperature of 25 °C, partial nitrification still takes place in this load range. According to Wolf, a maximum conversion rate (assumptions: 90 m^2/m^3 und 60 % active surface) of approx. 1 g NH_4-N/(m^2·d) is reached at 0.3 kg BOD_5/(m^3·d). With the same assumptions, approx. 2 g TFN/(m^2·d) (total elimination including incorporation) are reached at 25 °C and 1.2 kg BOD_5/(m^3·d). Hence, at higher temperatures there is potenzial for targeted "partial nitrification". Depending on the local requirements for the discharge quality, higher volumetric loads can be set for this.

Highly-loaded plants may exhibit more serious operating problems (blockages, odours, etc.) as a result of the high sludge production. The rinsing forces of maximally 30 mm set during operation were not sufficient for blockage-free operation. In order to improve the discharge of sludge and to avoid operating errors, a flat trickling filter was examined subsequent to the investigations illustrated here in order to check whether the sludge produced in the upper layers of the trickling filter can be discharged faster due to the shorter flow distance of the trickling filter. Apart from that, flat trickling filters can be more economical with regard to operating and investment costs (water hoisting, statics of the filter construction and the packing material). To this end the semi-scale trickling filter was reduced in height by half (1.8 m packing material height) and operated further with a volumetric load of 1.0 kg BOD_5/(m^3·d) and a rinsing force of 50 mm. The results showed that similar cleaning performances can be achieved with the flat trickling filter. However, flat trickling filters require particular attention to be paid to wastewater distribution and load peaks. In addition, the rinsing force setting was partly insufficient for maintaining a low biofilm thickness, so that further investigations are necessary in order to check the operating condition on large-scale industrial plants. The complete results from these investigations can be taken from [12].

4 Information on the dimensioning and operation of trickling filter plants at high temperatures

In the low volumetric load range, no improvement in the carbon elimination or nitrification can be determined in comparison with the data from literature due to the maximum efficiencies having already been reached. Conversely, this means that the dimensioning specifications in worksheet ATV-DVWK-A 281 [6], with the goal of complete nitrification even at higher temperatures, are valid.

As the volumetric load increases, on the other hand, comparatively better cleaning performances are observed at high temperatures. For carbon elimination only with lava slag trickling filters, a volumetric load of 1.0 kg BOD_5/(m^3·d) is possible at a wastewater temperature of 25 °C, which means a saving on volume of 60 % in comparison with the specifications in worksheet ATV-DVWK-A 281. Even higher volumetric loads can be set with plastic trickling filters. Due to the various properties of plastic packing materials types, however, this should be proven by means of tests or references when planning.

Partial nitrification still takes place at high temperatures with high volumetric loads. Since the dimensioning approaches employed so far always assume complete nitrification and do not aim for concrete nitrogen discharge values or degrees of degradation, this potenzial has not been specifically utilised to date. In particular in developing or emerging countries with less strict monitoring requirements, this must be critically questioned. The results from the semi-scale trickling filter can serve as an orientation aid for the design of trickling filter plants at high temperatures with the goal of partial nitrification.

A mathematical model based on the classic biofilm theory for the simulation of the semi-scale trickling filter was implemented in [12] and, building on this, a new dimensioning approach was developed on the basis of the test results for various temperatures. This offers a good alternative for the design of trickling filter plants in hot climatic zones.

Particular attention needs to be paid to the reliability of the plant if high volumetric loads are set. Trickling filter plants with volumetric loads exceeding 0.4 kg BOD_5/(m^3·d) for lava slag or 0.6 kg BOD_5/(m^3·d) for plastic packing material can exhibit problems with blockages and odours. The following notes should be observed with regard to the operation of highly loaded trickling filter plants:

- Flat trickling filters can also be operated in order to facilitate the discharge of sludge from highly loaded trickling filters. A minimum packing material height of 2 m is recommended, wherein, for reasons of safety, consideration must be given to upstream buffer tanks for the avoidance of discharge peaks for heights of between 2 and 3 m. The use of buffer tanks additionally contributes to even wastewater distribution and rinsing force (if there is no motor-driven rotary sprinkler).
- If flat trickling filters are employed, fine adjustment of the wastewater distribution is necessary, for example using baffle plates. It is recommended here to balance the local surface feeds for the various trickling filter radii.
- A minimum value for the surface feed of 0.4 m/h for the lava slag or 0.8 m/h for the plastic packing material is to be adhered to on the basis of worksheet ATV-DVWK-A 281. The discharge may need to be recirculated in order to reach these values.
- Since the sludge production depends on the organic load, a suitable rinsing force should be selected according to the organic load; on account of the lack of experience in Germany, the volumetric-load-dependent rinsing forces recommended by the American Water Environment Federation (WEF) [13] can serve as an orientation aid.

In regions where the air/water temperature differences lie between -2 and +2 °C over a large part of the day, it is possible that the trickling filter will not be adequately aerated by natural convection. In critical cases the use of artificial aerators may be necessary. The dimensioning of the aerator should be based on an air flow of at least 4 l/(m^2·s). This value is based on the temperature difference achieved in the climatic chamber. It is not known to what extent higher air flows contribute to an improvement in the cleaning performance.

The surplus sludge production for both packing materials can be assumed to be 0.4 g SS / g COD_{elim}. The ignition loss increases together with the volumetric load. At approx. 0.2 kg BOD_5/(m^3·d) the ignition loss lies between approx. 55 and 70%, at approx. 1.0 kg BOD_5/(m^3·d) it lies between approx. 65 and 80%.

Due to the high void content, the plastic trickling filters tend to be better aerated than the lava slag trickling filters. On the other hand, the larger pores of the plastic packing materials facilitate the reproduction of trickling filter flies (*Psychoda* *sp.*) in deeper trickling filter layers. The reproduction of trickling filter flies in the deeper trickling filter layers is by comparison not so intensive in the case of lava slag. In the case of a fly infestation and a weak load, the nitrification in particular and also the carbon elimination of both packing materials can be impaired. Conversely, a moderate fly infestation can even be advantageous, since the biofilm is kept thin.

Financial and spatial aspects should also be taken into account when choosing between lava slag and plastic packing material. The plastic packing material enables the construction of trickling filters with smaller volumes and makes fewer constructive demands (statics, weight) in comparison with lava slag, but can be financially less favourable per unit volume. Lava slag or similar boulder-filled packing materials are natural materials and may therefore be more readily available, but require a larger volume depending on the requirements for the discharge quality.

5 Prospects

On account of the introduction of legal requirements for nitrogen elimination, the trickling filter method has been largely replaced in Germany by the activated sludge method, since the realisation of the denitrification was difficult and there are fewer possibilities to control the processes. Research into denitrification with the trickling filter method [14] was not carried out until the 1990s, by which time most wastewater treatment plants in Germany had already been built. Some disadvantages of wastewater cleaning using trickling filters also contributed to the relatively modest prevalence of the trickling filter technology. The few possibilities to control the processes and above all operational problems should be mentioned here.

However, there are a sufficient number of cases in which the trickling filter method has proven to be very competitive. However, the selection of the wastewater cleaning process depends strongly on the respective local boundary conditions, such as costs, electricity supply, population growth, discharge quality requirements, qualification of the operating personnel, etc. Since the artificial aeration of trickling filters is not usually necessary, the energy costs of the trickling filter can be kept low. This advantage is partly restricted in the case of trickling filters with nitrogen elimination, since the necessary return transport requires considerable energy if the topography is unfavourable.

The trickling filter is particularly suitable in less developed regions as part of a gradually growing wastewater treatment structure. A nitrogen elimination stage can still be retrofitted in future. If, for example, a trickling filter is designed solely for carbon elimination, then operation without recirculation and requiring no energy is even possible if topographical conditions are favourable. This can be of advantage in regions that are far removed from an electricity supply, or where the electricity supply is not yet reliable.

A further large advantage of the trickling filter method lies in its simplicity compared to other methods. Since an understanding of complex interrelationships is not required for the operation of the trickling filter method, technical problems can be identified and rectified more quickly. The trickling filter method is therefore very suitable for less qualified personnel. On top of that, trickling filters have few wearing parts. This is a further advantage in emerging and developing countries, since few spare parts are required that may be difficult to obtain.

Thanks

The authors wish to thank the Federal Ministry of Education and Research for its sponsorship of the research project “Use of the trickling filter method under country-specific influencing factors” within the context of the joint project “Export-orientated research and development in the field of water supply and disposal”.

Literature

[1] Gebert, W.: *Einflussfaktoren auf die Leitungsfähigkeit kunststoffgefüllter Tropfkörper*, Berichte aus Wassergüte- und Abfallwirtschaft, Bd. 159, TU München, 2001

[2] Honda, Y., Matsumoto, J.: The Effect of Temperature on the Growth of Microbial Film in a Model Trickling Filter, *Water Research* 1981, *17* (4), 375–382

[3] Parker, D. S.: Trickling Filter Mythology, *J. Environ. Eng.*, 1999, *125*, 618–625

[4] Wolf, P.: Betriebserfahrungen an Tropfkörpern, *GWF – Wasser/Abwasser* 1984, *125* (4), 186–193

[5] Horn, H.: *Substrate conversion and mass transport in biofilm systems – experiment and modelling*, FIT-Verlag für Innovation und Technologietransfer, Paderborn, 2004

[6] ATV-DVWK-A 281: *Bemessung von Tropfkörpern und Rotationstauchkörpern*, Hennef, 2001

[7] BS EN 12255-7: *Wastewater Treatment Plants – Part 7: Biological Fixed-Film Reactors*, London, 2002

[8] U. S. EPA 832-F-00-014: *Trickling Filters, Wastewater Technology Fact Sheet*, Washington, D. C., 2000

[9] U. S. EPA 832-F-00-015: *Trickling Filter Nitrification, Wastewater Technology Fact Sheet*, Washington, D. C., 2000

[10] Imhoff, K. R.: Betriebsergebnisse von Tropfkörperanlagen und Bemessungsvorschlag im Hinblick auf § 7a WHG, *GWF – Wasser/Abwasser* 1979, *120* (2), 46–49

[11] ATV-DVWK-A 131: *Bemessung von einstufigen Belebungsanlagen*, Hennef, 2000

[12] Pressinotti, F.: *Anpassung der Tropfkörpertechnologie an heiße Klimazonen*, Dissertation, Stuttgarter Berichte zur Siedlungswasserwirtschaft, Bd. 205, Stuttgart, 2010

[13] Metcalf und Eddy: *Wastewater Engineering, Treatment and Reuse*, 4. Aufl., McGraw-Hill, New York, 2003

[14] Dorias, B.: *Stickstoffelimination mit Tropfkörpern*, Stuttgarter Berichte zur Siedlungswasserwirtschaft, Bd. 138, Stuttgart, 1996

Authors

Dr.-Ing. Fabio Chui Pressinotti, M. Sc.
Dahlem Beratende Ingenieure GmbH & Co. Wasserwirtschaft KG
Poststraße 9, 64293 Darmstadt, Germany

Dr.-Ing. Jörg Krampe
SA Water
250 Victoria Square, Adelaide SA 5000
GPO Box 1751, Adelaide SA 5001
Adelaide, Australia

Prof. Dr.-Ing. Heidrun Steinmetz
Institut für Siedlungswasserbau, Wassergüte- und Abfallwirtschaft der Universität Stuttgart
Bandtäle 2, 70569 Stuttgart (Büsnau), Germany

e-mail: f.pressinotti@dahlem-ingenieure.de

Modernization of the Iranian Wastewater Sector and Cooperation Opportunities for German Companies

Shahrooz Mohajeri (Berlin, Germany)

Abstract

Modernization of the Iranian water management sector has taken place at a breathtaking speed. After a period of standstill in the wastewater sector following the Islamic revolution, the range of technical measures in this field as well as the great variety of accompanying measures are really impressive. Reorganization of water management structures, privatization activities, adjustment of tariff systems, elaboration of new standards, capacity development are just a few examples of measures that are currently undertaken to optimize the sector. Thus, Iran constitutes an interesting market for German water management companies, which is hardly known and not yet sufficiently exploited.

Key words: international cooperation, economy, water management, Iran, modernization, privatization, wastewater sector, continuing training, market

1 Introduction

Water is an increasingly scarce resource in Iran: quantitatively decreasing and qualitatively worsening water resources must be distributed to a growing population with increasing needs for potable water. It is all the more urgent to protect available resources against contamination and to develop the wastewater infrastructure.

From a historical point of view, German companies play an important role in the modernization of the Iranian water and wastewater sector and can be said to be the most important foreign partner in the Iranian water management business today. The size of the country, with over 74 million inhabitants and a solid economic growth rate of 5.6% p.a. on average, but also increasing environmental awareness among the protagonists, makes Iran an interesting market for German environmental technology.

To date, however, virtually no information has been available to provide German companies and science with a focused view of the Iranian water management business. This article is intended to fill this gap in the field of urban wastewater disposal, since this sector will be at the focal point of the Iranian government's investment projects in the coming years.

Following a brief sketch of some of the boundary data of the Iranian water and wastewater sector, the article initially casts a glance back to the time following the building of the first modern disposal systems in the 1970s and then describes the main points of the current water management situation.

Despite massive investment and increased effort in the wastewater sector in recent years, the need for action remains large. Against this background, the goals set by the Iranian government for the future development of the sector as well as measures to improve the structural boundary conditions will be outlined in the final section.

2 Boundary data of the Iranian water and wastewater sector

Around 70% of the present 77.6 million inhabitants of Iran live in cities and 30% in rural regions. With a connection rate of 99%, the Iranian cities are almost comprehensively connected to the potable water supply [1]. In rural regions, 72% have access to hygienically flawless potable water. The situation is different where wastewater is concerned: The seepage of wastewater directly at the point where it is produced is still common practice, both in the country and in cities. Only about one quater of the total population is connected to a sewer to date. This is associated with increasing problems, such as poor hygienic conditions, groundwater contamination and the endangerment of natural resources.

This particularly affects the eight Iranian cities whose populations exceed one million people, together making up a good third of the 55.8 million city dwellers. The remaining 37 million city dwellers are distributed over a total of 800 towns. As

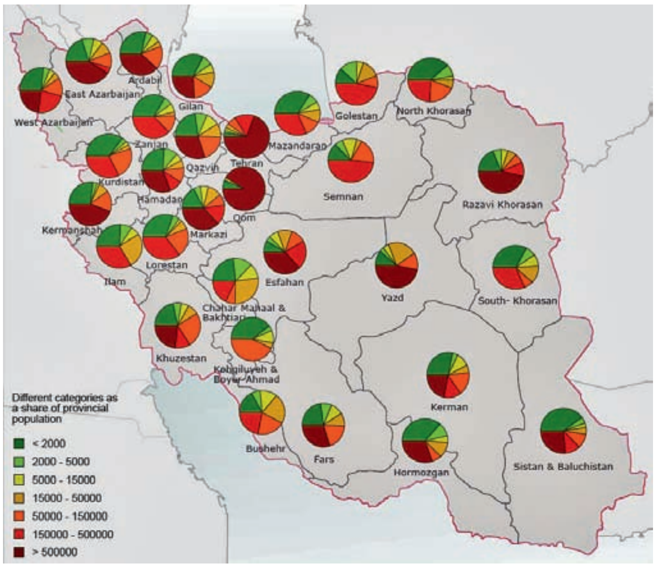


Fig. 1: Population ratios in the respective provinces according to settlement size (own illustration)

Fig. 1 shows, the settlement structure in the 31 Iranian provinces differs strongly.

The capital city region is thus strongly urbanised. The north west of Iran and the dry provinces in central Iran such as Qom, Isfahan and Yazd exhibit high rates of urbanisation. Conversely, the mountain and border regions in the west and south west, the Caspian Sea coast and the east of the country are more rural, with the exception of a few cities.

The rapid growth in the number of households is also of interest to the water and wastewater sector however: Since 1991 the average size of an Iranian household has continually shrunk from 5.2 persons per household to around 4 persons today [2]. This led to an over-proportional increase in the number of households in comparison with population growth from 10.7 million in 1991 to 17.5 million in 2006 and an estimated 18.5 million households in 2009. The correspondingly strong demand for new living space also results in increasing demands on the development of the water and wastewater infrastructure.

The striving for one's own household and the increased need for household comfort are also no doubt results of the solid growth on the Iranian economy in the more recent past, although it has also been weakened lately by the financial crisis: hence, according to the International Monetary Fund, the GNP increased on average by 5.6 % p.a. to 332 billion US dollars in 2009 or 4477 US dollars per person (adjusted for inflation) [3]. At the same time, unemployment decreased from 14% in 2000 to 10.6% in 2009 [3]. Nevertheless, the *World Fact Book* described 18% of the population as poor in 2007 [4].

A further special feature of water management in Iran that should be mentioned is the extremely unequal distribution of the scarce water resources, with a comparatively low and constantly decreasing availability per head. The climatic diversity of the country can be illustrated on the basis of the climate diagrams shown for the cities of Rasht on the Caspian Sea, Yazd in Central Iran and Shiraz in the southern foothills of the Zagros mountains (figure 2): whereas the side of the Elburs mountains facing the Caspian Sea has precipitation of over 1000 mm, Central Iran, enclosed by the border mountain ranges is characterised by precipitation amounts of less than 100 mm for the most part due to its semi-arid to arid climate. The remaining parts of the country exhibit average precipitation amounts of 300 to 500 mm, with high rates of evaporation in summer.

The situation regarding renewable water resources is increasingly problematic: The availability of water resources per head is continually decreasing, from 7000 m³ in 1956 to less than 1900 m³ today [5]. Hence, Iran's share of the world's water resources is around 0.36 % today, while making up 1% of the world's population. It is forecast that only 1500 m³ water per head will be usable by 2020 and that Iran will thus fall below the critical limit for water scarcity according to Falkenmark (water-stress level). In this respect the problem of the lack of water in the country will significantly worsen, especially if a turnaround in the disposal of wastewater is not realised soon in order to drastically reduce the constant contamination of the available water resources.

3 Historical development of wastewater disposal

The history of urban wastewater disposal systems in Iran begins in the second half of the 20th century. The development that has taken place since then can be coarsely described in two phases:

- In the first phase, several cities created the initial basis for a modern wastewater disposal system in the 1970s. Up until then, domestic wastewater in Iran seeped almost exclusively in soakaways. Sewers were only laid where imperme-

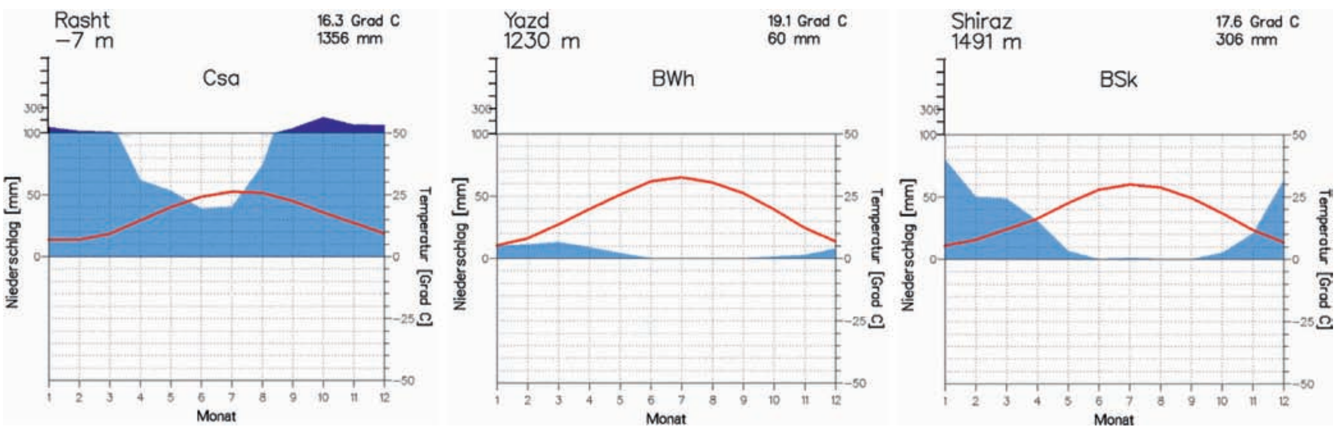


Fig. 2: Climate diagrams for the cities of Rasht, Yazd and Shiraz (source: Lacunosa Wetterberatung, www.klimadiagramme.de)

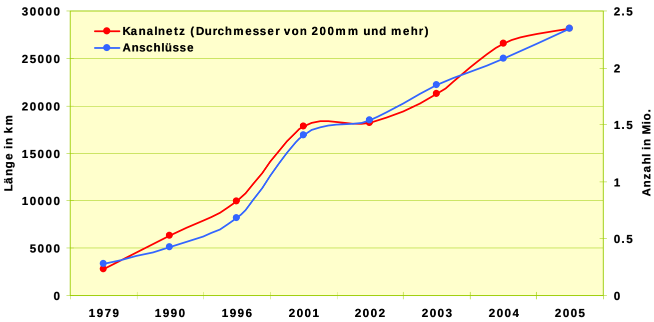


Fig. 3: Development of the length of the main sewer network and the number of wastewater connections (own illustration)

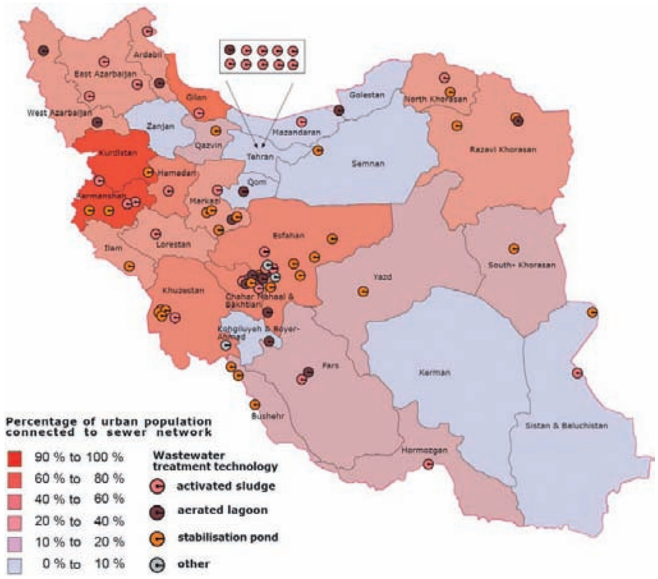


Fig. 4: Rate of connection to the urban sewers and number and technology of the existing wastewater treatment plants in 2008 (own illustration)

able ground or poor hydrogeological conditions prevented seepage, but without subsequent wastewater cleaning. The first modern wastewater disposal system with wastewater treatment plant was built in the city of Isfahan at the end of the 1960s/beginning of the 1970s. In 1979 there were wastewater treatment plants only in the cities of Isfahan and Teheran.

- In the 1980s (following the revolution), activities in the wastewater sector stagnated due to various reasons such as the war with Iraq. Following this stagnation phase, an important signal was set at the beginning of the 1990s for a new dawn with the establishment of urban water and wastewater companies and the reorganisation of the water and wastewater sector. This new beginning, combined with the first five-year development plan (1990-1994) now gave new impetus to the development of the urban wastewater sector in the 1990s. From the mid-1990s onwards, the government began with the construction of wastewater systems in cities on a large scale with the aid of the World Bank and the Islamic Development Bank. Therefore the number of wastewater treatment plants increased more than four times over from 1996 to 2005 [6], while the sewer length and the number of connections approximately tripled (Fig. 3).

Development proceeded at different speeds in different parts of the country, so that the present-day situation in the wastewater sector is very differentiated, as described below.

4 Current situation in the Iranian wastewater sector

Despite the accelerated development of the wastewater infrastructure since the mid-1990s, only 25% of the total Iranian population are currently connected to a sewer, and these are almost exclusively city dwellers [7]. In relation to the cities alone, the connection rate is around 35%, or almost 19.6 million of the total of 55.8 million city dwellers.

Fig. 4 shows the proportion of the urban population with a connection to the sewer network as well as the type and number of existing wastewater treatment plants. Both vary extremely from region to region. Provinces in which the connection rate lies below the national average are marked in blue-grey and red-grey; provinces with an average to well-above-average connection rate are marked in bright-red to red. The sewer network tends to be considerably denser in the western provinces than in the rest of the country. This results in particular from the aforementioned geological conditions that prevent seepage of the wastewater. As opposed to this, the capital city of Teheran lies well below the national average values; however, efforts are currently being intensified to expand the sewer network here. Problems caused by wastewater seepage are worsening here, such as the contamination of potable water wells and rising groundwater levels in the lower southern districts of the city. The cities with the lowest connection rate are Zanjan, Kerman, Golestan, Mazandaran and finally Semnan.

Considerable progress has recently been made in the cleaning of the wastewater produced: whereas in 2005 only about half of the total 480 million m^3 of wastewater collected was cleaned in the approx. 80 wastewater treatment plants existing at that time, this proportion has increased to 126 wastewater treatment plants today. The total capacity of the operating wastewater treatment plants has more than doubled to around 1260 million m^3.

These cleaning capacities are distributed very unevenly between the provinces, however: as the map shows, there are hardly any wastewater treatment plants at all in some provinces, for example Kurdistan, Hamadan, Khuzestan and Gilan, even though some of them have a developed sewer network. Conversely, other provinces with a low connection rate such as Teheran, Qom and provinces further to the east can clean 75 to 100% of the wastewater collected. An even development of sewers and wastewater treatment plants is taking place in the provinces of Isfahan und Kermanshah, where both the sewer network and wastewater treatment capacities are well developed and around 50% of the total wastewater produced is cleaned.

Approximately three quarters of the wastewater treatment plants in operation have been built since 1995. About 55% of the wastewater is cleaned in activated sludge plants, 26% in stabilisation ponds, 17% in aerated lagoons and around 2% using other methods.

5 Current challenges

Despite advances in the development of the wastewater technology, the situation in the major part of the country is still a long way removed from the goals of an environmentally-friendly and sustainable wastewater management. In view of the dynamic population development, increasing water consumption per head and the lack of funding and skilled workers, the challenges for the future are large.

Increasing consumption of water

As can be seen from Fig. 5 and 6, the need for potable water in Iran is continuously growing. In recent times the water consumption per head has even risen more sharply than the size of the population (Fig. 5). Whereas the population growth of 13.3 % was about twice that of the water consumption in the period from 1995 to 2000, the ratio reversed from 2000 to 2005: The demand for potable water increased over these five years by 30%, while the population growth slowed to 9.5%.

Fig. 6 shows that this trend will continue in the long run. The diagram shows the foreseeable future increase in the nationwide amounts of domestic wastewater produced. It was calculated taking into account the predicted population growth, the water consumption and the amount of infiltration water among other things.

In the best and worst-case scenario funnel, there are roughly three scenarios:

- If water saving measures take effect in future and achieve their goal (scenario 3 in Fig. 6), the present average per-head water consumption of 195 l per person per day can be reduced to 180 l by 2025. That would be roughly equivalent to the present-day average consumption in southern European countries. However, on account of the growth in population alone as well as an increasing proportion of the population with a potable water connection, the total water consumption and, as result of that, the amount of wastewater will increase over the same period by at least one fifth of the present amount to around 5.7 billion m³.
- If the water-saving measures that have been initiated continue to show hardly any effect (scenario 2), it can be assumed that the individual water consumption will remain around the present level of 195 l/person/day. That would mean an increase in wastewater amounts of at least one third to 6.3 billion m³ by 2025.

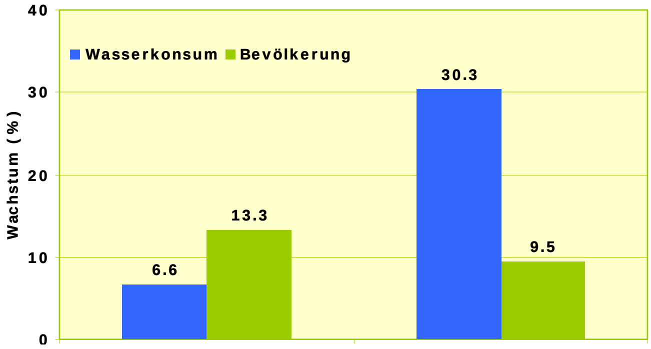


Fig. 5: Comparative development of water consumption and population (own illustration)

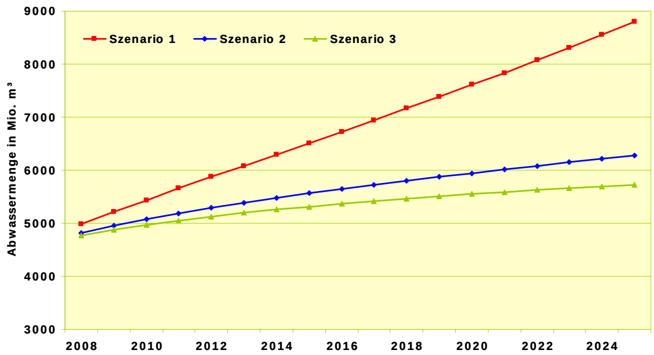


Fig. 6: Predicted future development of wastewater quantities in Iran (own calculations).

- However, if not only the number of consumers, but also the water consumption per head continues to increase to 275 l/person/day (scenario 1), then a virtual doubling of the amount of wastewater produced to up to 9 billion m³ is foreseeable.

From the discrepancy between water requirement and water availability, it follows that wastewater treatment will become more and more important, on the one hand in order to protect the resources against contamination and on the other in order to reuse the cleaned wastewater as a substitute for potable water, for example for irrigation purposes.

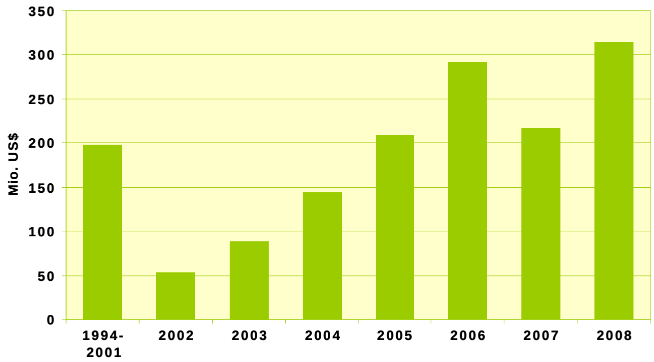


Fig. 7: Annual losses of all urban water and wastewater companies in Iran (own illustration)

Financial and management deficits

The growing need for action is opposed both financially and operatively by weakened water management protagonists. Due to the politically and centrally specified tariff level, which is too low, the urban water and wastewater companies are suffering annual operating losses that are in addition increasing from year to year, as Fig. 7 shows. The losses of all 34 companies ran to 1.5 billion US dollars in total between 1994 and 2008. Hence, the companies will be unable to settle their debts within a foreseeable period even under favourable boundary conditions.

Beyond financial problems, a lack of regional decision-making authority and independent control is leading to a climate of unclear responsibilities. Although the urban water and wastewater companies are formally organised as companies under private law and are largely autonomous, in practice the state and the provincial or urban authorities as the largest owner exert a direct influence on important company decisions, such as questions of personnel and investment projects.

Lack of skilled workers

A further hurdle facing the Iranian wastewater sector is the lack of experienced, skilled workers. In particular in cities and regions far from the boom regions of Teheran, Isfahan and northwestern Iran, there are an insufficient number of experienced engineers and specialists for the construction and operation of above all technologically more complex plants and processes. This situation is all the more difficult since specifically regional solutions for wastewater disposal are called for in Iran instead of standardised solutions on account of the hydrogeological conditions, which vary widely from region to region.

Furthermore, there are insufficient educational and training capacities in order to be able to train an adequate number of technical personnel fast enough and with the appropriate qualification for the operation of the plants. Wherever there is a lack of experience and knowledge of innovative technologies and processes, however, these cannot be used to the optimum, which means that investments cannot develop their full effectiveness. In addition to that, the service lives of plants that are not properly serviced and maintained are shortened.

6 Objectives

The Iranian government has initiated a series of measures in order to gradually rectify the deficits in the water and wastewater sector. Clear objectives for the development of the wastewater infrastructure have been formulated as a guiding theme. At the same time, however, an attempt is being made to reduce the consumption of potable water and thus also the amounts of wastewater produced. On top of that, the national policy-makers and international partners have taken the first steps towards improving the situation of the companies and toward the training and further training of technical personnel.

Development of the infrastructure

In 2004 the government drew up an “outlook plan” for the future development of the water and wastewater sector. This provides for 60% of city dwellers and 30% of the rural population to be connected to the wastewater infrastructure by 2025 (Table 1). In the case of the potable water supply, 100% is to be achieved in each case.

This objective is ambitious, in particular for the wastewater sector, and, in view of the current actual values and the challenges described, the goals appear to be difficult to realise.

An international comparison of the absolute figures, however, produces an absolutely realistic scenario: According to a United Nations forecast, 87 million people will be living in Iran in 2025, of whom 68 million will be city dwellers. Accordingly, a further 21 million inhabitants must be connected by 2025, in addition to the nearly 19,6 million who are already connected, in order to reach the target of 60%. Added to this there are 5 million rural inhabitants. Added together, the two figures correspond to 30% of the total population predicted in 2025. Similar progress was made between 1990 and 2005 in EU countries such as Portugal, Spain, Ireland and Greece, as well as in Turkey.

In addition to investments in main sewer systems, the massive expansion of wastewater treatment plant capacities is planned in order to cover the present deficit and also to completely clean the future increasing amounts of collected wastewater.

Connection rate [%]	2005	Goal 2009	Actual value today	Goal 2015	Goal 2025
Potable water (urban)	98	100	99	100	100
Potable water (rural)	62	88	72	94	100
Wastewater (urban)	24	40	35	49	60
Wastewater (rural)	0.5	8	0.25	16	30

Table 1: The Iranian government’s outlook plan of 2005

Limitation of water consumption

Strategies for the protection of water resources are applied not only on the supply side, but also on the demand side. Hence, cleaned wastewater is increasingly perceived as a valuable resource: there is particular interest in its reuse in agriculture, in addition to which use of the energetic potenzial of the sewage sludge is planned. In particular in dry regions, the collection and cleaning of wastewater for irrigation purposes is becoming more important with the increasing growth of the agricultural sector.

With the objective of a reduction in water consumption and more efficient consumption-based billing, monitoring programs are currently ongoing in the network and in selected households in Teheran. In cooperation with German companies, online measuring systems have been developed for the operation of potable water networks and for the recording and analysis of household consumptions under particular technical and socio-economic boundary conditions. This enables the design of optimally adapted measures for the saving of water, taking into account the regional conditions of the country.

Strengthening of the water and wastewater companies

The planned investments in wastewater can be funded by the state – sufficient budgetary funds are available annually. The government is additionally supported by loans from international financial institutions. In order to implement the investment plans, however, and in particular to ensure smooth operation of the systems, the main protagonists from the water and wastewater sector – the regional companies – need to be backed up both financially and operatively.

Two reform approaches are being pursued in this respect: on the one hand, cost-covering water and wastewater tariffs are to be gradually introduced nationwide over the next few years. On the other, the privatisation of the water and wastewater companies will be expedited. Both goals require greater freedom of decision-making and action to be delegated to the companies. A greater degree of autonomy is therefore to be granted to the companies, both with respect to management decisions and with regard to their financial planning. Apart from the introduction of cost-covering tariffs, the companies should be placed in the position of being able to implement the already legally compulsory connection more consistently in collaboration with local public order authorities in order to improve their income basis.

Capacity building

Efforts to train technical personnel have been considerably strengthened in recent years. With international help, a large number of training programs have been conducted for management, supervisory staffs and operating personnel.

Together with the UNESCO-IHE Institute for Water Education, the Power and Water University of Technology Teheran, for example, has conducted a comprehensive program of education for 2100 Iranian skilled workers from 2008 until today, which was funded by the Iranian government. The objective of the program was further education in the areas of water and wastewater technologies, planning and management within the scope of 60 courses as well as 20 field study trips to European water and wastewater companies.

7 Conclusion

Fast and decisive action is demanded so that, as the scarcity of water increases, Iran can secure and maintain the supply to the population and the economic growth trend. The boundary conditions for a modernisation of the Iranian water and wastewater sector were already created with the restructuring that began in the 1990s. In order to cope with the current challenges, the country now needs international cooperation partners more than ever before, and there are a large number of potenzial fields of action, above all for the German water and environmental industry.

In conjunction with the financial challenges, urgent strategies for structural reorganisation and adaptation are necessary for the modernisation of the Iranian wastewater sector. In addition, innovative ideas and concepts are called for to enable efficient wastewater cleaning and reuse as well as effective consumption management. The objective is to train the technical and operating personnel from the Iranian water and wastewater companies with the aid of German and international partners and to support the companies on their way to a solid economic and administrative independence.

Establishment of contacts

Various industrial institutes, including the German Water Partnership (GWP), as well as the Federal Government of Germany can assist with the establishment of contacts and business relationships. The GWP's goal is to strengthen the competitive position of industry and research on the international markets by combining private and public companies from the water industry, professional associations and institutes from industry, science and research under one roof. Within the context of a special country forum for Iran, the GWP helps with the initiation of contacts and the establishment of business relationships in particular with protagonists in Iran.

www.germanwaterpartnership.de

Literature/remarks

[1] All data concerning the Iranian water sector, last access: 15.04.2012, *www.moe.org.ir*

[2] Statistical Centre of Iran, 2010, *www.amar.org.ir/default.aspx?tabid=19*

[3] International Monetary Fund, 2010: *IMF Country Report No 10/74*, *www.imf.org/external/pubs/ft/scr/2010/cr1074.pdf*

[4] *https://www.cia.gov/library/publications/the-world-factbook/geos/ir.html*, last access: 15.04.2012

[5] FAO, 2010: *Aquastat Country Fact Sheet Iran*, *www.fao.org/nr/water/aquastat/data/factsheets/aquastat_fact_sheet_irn_en.pdf*

[6] Today, in Iran there exist more than 119 wastewater treatment plants. Furthermore, 114 sewage treatment plants are currently under construction.

[7] In rural areas, only 0.5 % of the inhabitants are connected to sewers.

[8] UN Department of Economic and Social Affairs, 2009: *World Urbanization Prospects*, *http://esa.un.org/unpd/wup/unup/p2k0data.asp*

Author

Dr. Shahrooz Mohajeri
inter 3 – Institute for Resource Management
Otto-Suhr-Allee 59, 10585 Berlin, Germany

e-mail: mohajeri@inter3.de

KA

Water Reuse: Diverse Questions in View of an Internationally Increasing Relevance

Tim Fuhrmann, Holger Scheer (Essen, Germany), Peter Cornel (Darmstadt, Germany), Stefan Gramel and Alexander Grieb (Frankfurt a. M., Germany)

Abstract

In view of growing international demand for water and limited natural water resources, the reuse of wastewater as an element of sustainable water resource management will gain more and more importance. Although water reuse is a well-established practice in many regions of the world, especially for agricultural irrigation, projects for reuse of treated wastewater are still a complex task for consultants, equipment suppliers and plant operators. In addition to the usual process-engineering issues relating to wastewater treatment, several further constraints including institutional, economic and socio-cultural aspects which vary from country to country have to be taken into account. The DWA publication series "DWA Topics" on "Treatment Steps for Water Reuse" contains several explanations of this topic; excerpts from this publication are included in the present article, which was published in a modified German version in KA – Korrespondenz Abwasser Abfall, issue 1/2012.

Key words: development co-operation, international, irrigation, municipal, reclaimed water, reuse, wastewater treatment

1 Need for action

Limited water resources and those impaired by human influences represent a global problem. This applies in particular to many emerging and developing countries in arid and semi-arid regions faced with high population growth, industrialisation and increasing water consumption. Unsustainable handling of available water resources, pollution of surface and groundwater as well as high water losses in distribution networks exacerbate the problem in many places. The UNESCO [1] world water report forecasts that if consumption habits remain unchanged, at least two billion people in 48 countries will be suffering from drought by the middle of this century; in the worst-case scenario it could be even 7 billion people in 60 countries. Additionally, experts from the Intergovernmental Panel on Climate Change [2] warn against a further worsening of the global water shortage due to the effects of global climate change. This gives rise to an increasing need for action, not only with regard to water-saving technologies and more efficient operation of water infrastructure, but also to the increased utilisation of treated wastewater.

2 International relevance of water reuse

The reuse of "used water" is a common practice of water management in numerous countries today. As a matter of fact it is an indispensable necessity in many places. In the future it will become a component of sustained water resource management in further regions, also as a measure for adapting to the effects of climate change. Treated wastewater, when appropriately purified in accordance with the requirements for its respective purposes, is thereby considered as a locally controllable water resource. Water reuse can help to reduce the gap between constantly increasing water consumption and limited natural water resources. In this regard, the resource-oriented tightening of environmental legislation in many countries (e. g. Australia and the USA) has given strong impetus to the reuse of wastewater over the last 20 years.

So far there are few reliable figures for water reuse as a percentage of worldwide water consumption (see for example fig. 1), but numerous current publications show a clear increasing tendency towards projects for regulated reuse (see for example [4–6]). On an international scale, the scope of application for the use of wastewater is very large: By far the largest water need arises from irrigation in agriculture; in addition, process

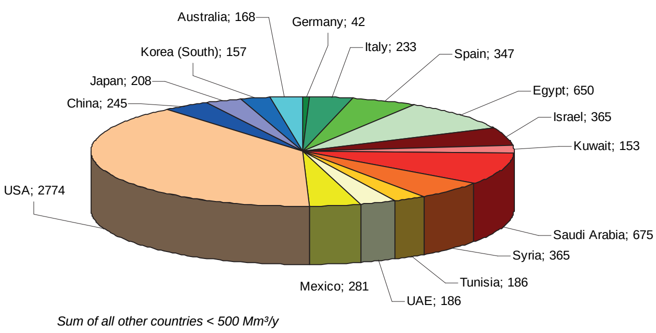


Fig. 1: Reused volume (mio. m³/a) for the largest reusers of treated wastewater worldwide 2008 (Sources: Jimenez & Asano 2008, NRC 2012 and diverse other sources on a country-basis) [3]

water is used in industry as well as in various applications in urban areas and tourist regions. In urban areas, demand comprises the irrigation of green areas and road cleaning as well as domestic applications [5, 6].

Especially the use of adequately treated wastewater for agricultural irrigation (as the largest water consumer worldwide) represents a particularly large potential for preservating of fresh water resources. In the future, even in Europe – and not only in southern Europe, where agricultural reuse is already established today – this topic will require increased attention due to the effects of climate change.

3 Water reuse is a complex task

For sustainable water resource management it is important to recognise treated wastewater as a valuable resource, wherein the appropriate purification is absolutely indispensable. This means for example that health risks associated with water reuse have to be appropriately minimised on the one hand, while retaining soil fertility and reducing the danger of groundwater contamination on the other. However, in many developing countries where controlled wastewater collection and treatment are still under development, large-scale use of untreated or insufficiently treated wastewater for irrigation purposes exist, since the wastewater is produced free of charge and independent of dry periods, and in addition exhibits a high fertiliser value.

Although the technical processes of wastewater treatment for the various purposes of reuse are fundamentally well known, local conditions such as unclear responsibilities, uncertainties about applicable water quality standards, insufficient budgets and a lack of trained operating personnel represent complex challenges to the implementation and reliable operation of water reuse infrastructure. In order to ensure the sustainability of reuse projects, it is also absolutely essential to take into account ecological, institutional, economic and social aspects, among other issues. Some of these are described below.

4 Health aspects

The different ways of (re)using water give rise to respective minimum requirements for water quality. When using reclaimed water for agricultural and intra-urban applications it must be ensured that there are no dangers to the health of the operating personnel, the users of the water, the consumers of irrigated agricultural products and the population. In addition to residues from persistent chemical substances, this mainly concerns human-pathogenic microorganisms like bacteria, viruses, parasites and helminth eggs [4], [7], [8]. The safe and hygienically unreserved use of purified wastewater therefore requires specific demands on the water quality, in particular under epidemiological aspects. The quality depends strongly on the specific use of the treated wastewater, for example with regard to the irrigation method (drip irrigation versus sprinkler irrigation) and the type of crops.

These aspects must be observed accordingly both for the selection of the treatment technology and for tracking the production chain of agricultural products to the user. Both the operating personnel and the user of the treated wastewater must be instructed with regard to the specific health issues arising from the reuse of the water. Emergency plans and public information about controlled faults coordinated with all stakeholders involved increase both acceptance of the water reuse and trust in the systems and the products produced.

5 Legal regulations and their enforcement

In addition to defining (adapted) technical standards and specifications for water quality, national regulations for water reuse also have to cover requirements for safety measures, reporting and self-monitoring or external monitoring. Clear rules must be laid down for sanction mechanisms if these requirements are not fulfilled. Apart from that, the acceptance of the regulations requires compatibility with socio-economic constraints, such as the affordability of the specified treatment requirements (see paragraph 8).

In practice, in many emerging and developing countries some raw or insufficiently treated wastewater is used, with the associated risks involved. In countries with scarce water resources, this is often due not to a lack of rules or recommendations of minimum standards for water reuse, but rather is mainly a problem of adherence to these rules and their monitoring by the responsible authorities (lack of enforcement) resulting from insufficient budgets and a lack of infrastructure such as qualified laboratories.

In addition, the stipulated standards can often barely be met because of poor economic resources. The prohibition on using of improperly purified water, for example for cultivation of agricultural crops, also seems to be difficult to enforce if there is no affordable treatment infrastructure available. In these cases, however, it would be possible to implement multi-barrier concepts, in which only those irrigation techniques are only permitted that carry a low infection risk or to which additional hygiene measures are to be applied [7].

6 Technical challenges

The use of treated wastewater requires an extensive infrastructure, which exceeds the usual beyond the usual scheme of city drainage and encompasses storage, transport and distribution of the treated water in addition to the special treatment of the treated water in addition to the special treatment of the wastewater.

Particular importance is attached to the way wastewater is treated, since adequate treatment of the water is indispensable for the specific purposes of water reuse. For example, the use as irrigation water entails quality requirements with respect to hygienic parameters (protection of health), biologically degradable substances (avoidance of odours), inorganic substances (protection against salinity), nutrients (protection against over-fertilisation) and concentrations of solids (with regard to irrigation systems). For economic reasons, however, treatment only makes sense to the degree necessary to meet the minimum requirements for the respective application. For the selection of suitable water treatment and distribution technologies, extensive examples and guidelines are provided in reference literature worldwide (see for example [4], [5], [9]).

The interaction between the continual flow of wastewater and the intermittent, seasonally fluctuating need for the treated water represents a particular challenge. This may necessitate water storage (central or decentralised), which can be implemented both in storage reservoirs and in aquifers. The type of storage additionally raises the specific quality requirements for the water treatment (for example with regard to microbial contamination and nutrient content).

7 System management and operational expertise

If the entire system consisting of water treatment, storage, distribution and application cannot be operated as intended, then even the use of the best (i.e. most adapted) technology bears considerable risks. Depending on the complexity of the selected processes and technology, the operation of reuse infrastructure requires corresponding system management expertise. Due to the high requirements for the protection of health, personnel should be able and motivated to act responsibly. Therefore, apart from appropriate equipment there is a need for trained employees. For projects in emerging and developing countries, suitable education standards have to be developed and the required level of qualification must be ensured through adapted and regular training. This also encompasses coordination between water producer and user.

Especially in arid and semi-arid climatic zones, such requirements often conflict with the reality in the wastewater and irrigation utilities. Possible shortfalls include:

- unclear institutional responsibilities;
- inadequate budget for operation and maintenance;
- inadequate operational organisation and a lack of training;
- limited possibilities for further training at national level;
- payment of employees does not encourage them to assume responsibility;
- strict hierarchical management structures discourage assuming individual responsibility;
- low supplies of equipment; promised budget not permanently available.

Such circumstances represent an enormous challenge to the successful project implementation and can endanger the success of the investment project. In parallel to the development of the infrastructure, support skills must be developed that cover the entire span of plant operation expertise through to the user. The funding for this must be promptly provided and the development must receive professional support.

8 Socio-cultural aspects and acceptance of treated wastewater

Socio-cultural conditions, to a large degree, and possibly also inhibition thresholds need to be considered in all cases of application of water reuse that lead to a contact between the end consumer and the purified wastewater, whether in the form of treated process or potable water or through agricultural products irrigated by these.

Although the use of rainwater and slightly soiled wastewater is a long-standing tradition in many parts of the world and the use of animal and human excrement as an agricultural fertiliser is widespread, potential users have considerable reservations regarding to treated water. This includes among other things the perceived proximity to the contaminants that the treated water may contain. The acceptance of water reuse is highly dependent on the availability of alternative water resources. Furthermore, religious views in some regions restrict handling of treated wastewater. In these cases convincing efforts to raise awareness are required in order to eliminate prejudices. In this context it is important that the water reuse system is accompanied by a sufficiently strict safety regime that can guarantee adherence to the minimum standards for the respective type of reuse. Users of treated water must be able to rely on these standards and on the transparent handling of risks in order to build up trust and acceptance.

An open approach to handling all relevant questions and risks as well as the involvement of all stakeholders at an early stage in the planning and decision-making process are indispensable prerequisites for guaranteeing successful implementation and sustainable operation. At the same time, consideration must be given at least to the following topics, whose importance differs depending on local conditions:

- clear definition of institutional responsibilities,
- general conditions of water management (year-round water balance; demand versus supply),
- hygiene standards, health care and surveillance,
- technical requirements for the production and use of treated wastewater,
- operational requirements and expertise (including the number and qualification of the operating personnel, operational reliability),
- economic feasibility, taking into account (re)investment and operating costs as well as tariff acceptance by the consumer,
- environmental compatibility and sustainability, follow-up in cases of damage as well as damage containment, and
- regulatory aspects of the project and subsequent expansions.

9 Financial sustainability

The management of water demands via appropriate pricing for different types of use, like potable water, domestic, industrial or irrigation purposes, can contribute to more effective use of water as a limited resource and can be used specifically to promote the reuse of water (through specifically lower water tariffs than usually paid for groundwater and surface water). In the long term, the aim is full cost coverage in order to ensure the economic sustainability of water reuse projects.

Investors' own capital, state subsidies and loans used for funding new water reuse systems are subject to very different conditions. Feasibility studies, which examine alternative concepts and technologies and illustrate inexpensive solutions both for the investors (low investment or operating costs) and the users (suitable tariffs) are the basis for international development banks to provide funds. Numerous international examples of coordinated water reuse projects illustrate ways that economically reasonable investments can be made by applying of adopted frameworks, regulations and standards – hence ultimately through state regulation. Successful practical examples can be found in [4] and [10].

Fig. 2: Biological treatment and irrigation areas near Braunschweig (Photo: Abwasserverband Braunschweig, Germany)

10 Water reuse in Germany

In Germany, 95–97 % of the municipal wastewater is biologically treated [11] and mainly discharged directly into receiving surface water bodies. Due to sufficient freshwater resources, currently the reuse of purified municipal wastewater represents an exception with few applications for agricultural irrigation. Germany has long-standing experience with all types of water treatment technologies, but yet their application for water reuse is mainly focused on industrial water recycling. In recent years, various approaches have arisen in urban areas, often in the context of innovative sanitary concepts which include the use of grey water in private households.

The formerly widespread reuse for agricultural irrigation and the now discontinued operation of wastewater fish ponds arose historically in Germany from early municipal wastewater treatment measures which were implemented widely at the beginning of the 20th Century. Due to stricter immission regulations and discharge limits, the reuse of treated municipal wastewater was largely abandoned. Nevertheless, some water reuse systems are still active today. For example, in Braunschweig (fig. 2) urban slurry was deposited on light sandy soil as early as 1895 in order to improve the city's hygienic situation and the condition of the natural receiving waters as well as improve the soil quality of these areas. Today, the wastewater from the city of Braunschweig (approx. 22 million m^3 p. a.) is biologically treated completely by a modern wastewater treatment plant before being put to agricultural reuse in the summer months on an irrigation area of around 3,000 ha, such as for the cultivation of sugar beet, for which there are fewer hygienic concerns than for foodstuffs that are consumed directly and raw. There are discussions about the future cultivation of renewable biomass for energetic use. Groundwater enrichment and storage takes place in the winter months. The existing sewage fields serve as a natural buffer that compensates fluctuations in the wastewater treatment plant processes and protects the sensitive receiving waters.

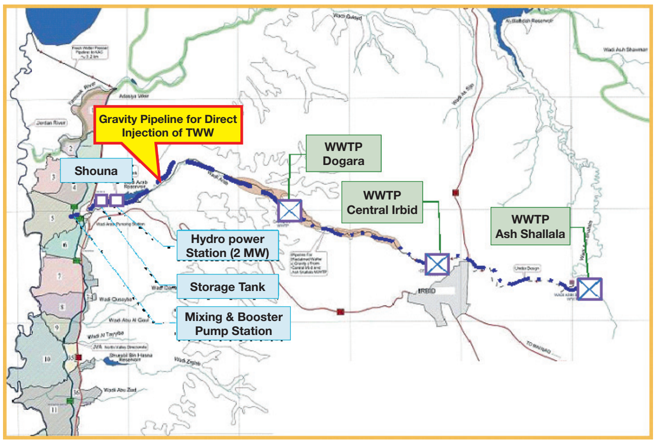


Fig. 3: Water reuse scheme in Northern Jordan Valley

11 German development co-operation for international reuse projects

Water reuse projects in various countries worldwide are part of German development co-operation activities. Within this context a particular focus lies on the water-scarce countries in the Middle East and North Africa. In the following, two project examples from Jordan and Tunisia are described.

Jordan, as the first example, is one of the most water scarce countries in the world. Its renewable water resources amount to only 120 m³/(a · resident) in comparison to e. g. USA with 6,800 m³/(a · resident). As a result, the water resources are facing tremendous over-use, resulting in the groundwater level of the main aquifers to decrease by more than 1 m per year. In the future, further developments may even worsen the situation: if the current population growth (approx. 2.5 % p. a.) stays the same, the population will increase by more than 60 % within the next 20 years. In addition, most climate models for this region forecast precipitation to decline considerably in the future.

This situation of water scarcity is the main driver for water reuse in Jordan. In the northern part of the country, a reuse scheme is currently under implementation with the support of German development co-operation through KfW (conceptual support with loans of approx. EUR 33 million for consulting, construction and a first phase of operation). The objective of this project is to treat the effluent of three wastewater treatment plants for agricultural irrigation in the Northern Jordan Valley. In this way, roughly 15-20 mio. m³ of freshwater can be replaced by reclaimed water per year. Fresh water – which today is used for agriculture – can be transported through the King Abdullah Channel to supply the population of Amman with an additional some 20 l per day per person. Furthermore, the difference in altitude between the wastewater treatment plants and the Jordan Valley allows a hydropower station to generate enough electricity for 10-15,000 people (fig. 3). Taking into consideration investment, operation and maintenance, the costs of the water for this reuse scheme are much lower than other conventional alternatives being assessed for new water resources in Jordan (mainly the water of the Disi aquifer). Currently, the design study for the reuse scheme is under preparation, to be followed by the tendering of construction services. The main components will be the expansion of the wastewater treatment plants (primarily filtration and disinfection), the pipelines, the hydropower station and facilities for blending the water.

In close co-operation with KfW, GIZ supports the water reuse efforts in Jordan through a range of activities in the field of technical co-operation (mainly the institutionalisation of the state crop monitoring programme, development of national standards for irrigation quality and a comprehensive risk monitoring and management system, as well as the support of farmers in the usage of treated wastewater).

In Tunisia, as a second example, water resources are under stress both in terms of quantity and quality. With less than 500 m³ of water available per person per year, the country is among those deemed as water-scarce. Today, already 95 % of the total renewable water resources are exploited, so developing new freshwater resources to meet additional demand is not feasible. Under these conditions, Tunisia has attained advanced practical experience in water reuse compared to other Arab countries in the MENA region. Meanwhile, the use of treated wastewater is an integral part of the national water resources strategy: 30 % of treated wastewater from 12 major wastewater treatment plants is currently reused (mainly for irrigation) on about 9,400 ha:

- 86 % for agricultural lands,
- 9 % for golf courses and hotel lawns,
- 4 % for green spaces and
- 1 % for groundwater recharge and wetland conservation.

Irrigation activities are particularly important in the Medjerdah catchment area, where a strong positive impact has been confirmed for the protection of scarce water resources through increasing wastewater treatment. The treated water is mainly used for irrigation of olive and other tree plantations, forage crops, industrial crops (cotton, tobacco) and grain crops. The extent of groundwater recharge will be expanded. Currently, KfW is supporting the preparation of a project implementation scheme in the Mornag region aimed at groundwater recharge for later irrigation purposes in agriculture.

The wastewater treatment plant in Kairouan (12,000 m³/d), co-financed by the German Government through KfW, has been designed for optional use of some of the effluent for irrigation purposes. Since the commissioning of the plant in 2008, ONAS as the responsible operator has been able to provide treated wastewater of acceptable quality in accordance with the Tunisian standards for irrigation. In this way, additional irrigation water can be supplied to an existing perimeter near Kairouan (distance about 5 km). The components of the wastewater treatment plant intended for water reuse comprise complementary tertiary treatment by filtration and UV disinfection as well as the transfer line to the perimeter, including a pumping station, and the connection hub to the irrigation network.

The (re)use of water and sludge from more than 110 existing wastewater treatment plants in Tunisia operated by ONAS will be a continuous challenge. German development co-operation is supporting the national partners in establishing appropriate concepts and in implementing the associated measures concerned.

12 Conclusion

The relevance of water reuse is increasing internationally. This topic represents a complex task which, beyond the technical questions of wastewater treatment, has to take into consideration many different aspects and implications. There is a particularly great need for advice and investment in arid and semi-arid climate zones (for example in Mediterranean countries). In order to guarantee the sustainability of projects for water reuse, not only the relevant process-related aspects and the specific adapted standards for water quality have to be taken into account (depending on the type of reuse and the local general conditions), but also numerous other aspects, like the institutional set-up, protection of health, soil protection in the case of agricultural irrigation, financial sustainability, training levels of the available operating personnel, socio-cultural influences and the consumer's acceptance of the reused water and the agricultural products irrigated with it. Additional benefits like the combination with energy production should be considered, as well, to increase the economic feasibility of water reuse projects.

Due to the globally increasing demand for water, a growing market is developing for water reuse. Additional infrastructure components will be required both for the treatment of wastewater, the intermediate storage and the creation of water-saving irrigation technologies. Tenders will be invited for planning, construction and equipment services in accordance with the level of development of the countries concerned and the specifications of the financing institutions like development banks.

13 DWA working group "Water reuse"

In view of the international challenges in the field of water reuse, DWA founded the working group BIZ-11.4 "Water reuse" in 2005. One of the tasks of the working group was to elaborate the DWA Topics on "Treatment steps for water reuse" [9], from which this article was partly extracted. Apart from the authors, the following additional members collaborated in the preparation of the DWA publication: *Edgar Firmenich* (Frankfurt a. M.), *Rüdiger Heidebrecht* (Hennef), Dr. E. h. *Hans Huber* (Berching), *Peter Kampe* (Maintal), *Volker Karl* (Frankfurt a. M.), *Alessandro Meda* (Darmstadt), Prof. Dr. *Hermann Orth* (Bochum), Dr. *Florian Schmidtlein* (Hannover), Dr. *Christina Hirschbeck* (Neubiberg) and *Klaus Weistroffer* (Eschborn).

References

[1] UNESCO: *Water – A Shared Responsibility, The United Nations World Water Development Report 2*, UNESCO Publishing, Paris/Berghahn Books, New York, 2006

[2] IPCC: *Climate Change 2007: Impacts, Adaptation and Vulnerability, Fourth Assessment Report, Summary for Policymakers*, Working Group II of the Intergovernmental Panel on Climate Change (IPCC), Brussels, April 2007

[3] Kompetenzzentrum Wasser Berlin: Presentation zu Reuse & OXI-MAR, 2012

[4] AQUAREC: Water Reuse System Management Manual, AQUAREC (Integrated Concepts for Reuse of Upgraded Wastewater), Editors: Davide Bixio and Thomas Wintgens, Office for Official Publications of the European Communities, Luxembourg, 2006, project summaries available at *www.aquarec.org*

[5] Asano, T.: *Water Reuse: Issues, Technologies and Applications*, McGraw-Hill, New York, 2007

[6] Jiménez, B.; Asano, T. (editors): *Water Reuse: An international survey, contrasts, issues and needs around the world*, Editors: Blanca Jiménez and Takashi Asano, IWA Publishing, London, 2008

[7] WHO: *Guidelines for the safe use of wastewater, excreta and greywater, Vol. 2: Wastewater use in agriculture*, World Health Organisation, Geneva, Switzerland, 2006

[8] U. S. EPA: Guidelines for Water Reuse. EPA/625/R-04/108, Produced by Camp Dresser & McKee Inc. for U.S. Environmental Protection Agency (U.S. EPA), Washington, USA, September 2004

[9] DWA: Treatment Steps for Water Reuse, DWA Topics, Editor: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA), Hennef, 2009

[10] EMWIS: Final report on wastewater reuse – Annex B – Case studies, November 2007, Results of the working group on water reuse, Euro-Mediterranean Information System on Know-how in the Water Sector, www.emwis.net/topics/waterreuse

[11] ATT, BDEW, BDVW, DVGW, DWA und VKU (editors): Profile of the German Water Industry, wvgw, Bonn, 2011

Authors

Dipl.-Ing. Tim Fuhrmann
Prof. Dr.-Ing. Holger Scheer
Emscher Gesellschaft für Wassertechnik mbH
Brunnenstraße 37, 45128 Essen, Germany
e-mail: fuhrmann@ewlw.de, scheer@ewlw.de

Prof. Dr.-Ing. Peter Cornel
TU Darmstadt, Institute IWAR
Petersenstraße 13, 64287 Darmstadt, Germany
e-mail: p.cornel@iwar.tu-darmstadt.de

Dr.-Ing. Stefan Gramel
Dipl.-Ing. Alexander Grieb
KfW Bankengruppe
Palmengartenstraße 5–9, 60325 Frankfurt a. M., Germany
e-mail: stefan.gramel@kfw.de, alexander.grieb@kfw.de

PE Sewer Piping Systems

Robert Eckert (Mannheim, Germany)

"Broken pipe" and "defective connections" by far represent the most common damages in sewers. These are typical for inflexible, brittle pipe materials. Plastic pipes respond to loads with flexibility: Flexible pipes can deform without compromising their performance. Plastic piping systems also offer a reliable method for joining technology. Already in 2002 a fusable PE sewage saddle was best in test of the Institute for Underground Infrastructure's product test [1].

For PE sewage pipes, electrofusion welding offers a reliable joining technique. Man whole connection, domestic sewer and pipe joints can be implemented with a fitting programme specifically developed for non pressure sewage systems. The consideration of the material selection for the sewer should focus today more than ever before on sustainability, economy, and reliability: arguments in favour of PE.

1 The selection of the pipe material in sewer construction

Sewage pipes are subject to complex stresses which consist of external and internal loads. External loads are primarily mechanical loads caused by static earth load, often in connection with dynamic traffic loads. Given high installation depths and groundwater level, resistance against outside pressure and buckling pressure are required. Because of the sewage water, the material must not only be resistant to chemical and microbial loads but also have a good temperature resistance and a high resistance to abrasion.

Figure 1 shows the typical loads exeted on a sewer piping system which have to be considered when selecting the material.

The condition of our sewer network is well-known meanwhile because of requirements imposed on the operator to regularly inspect sewers and drain pipes, to classify the damages and – resulting from this as cost-intensive consequence – to carry out repairs. The results of an inspection of pipes of

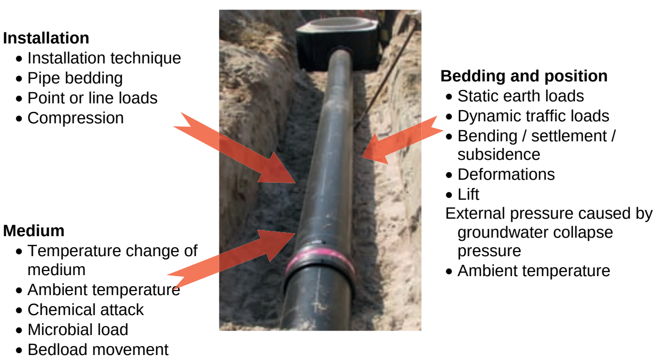


Fig. 1: Load types of a sewer piping system

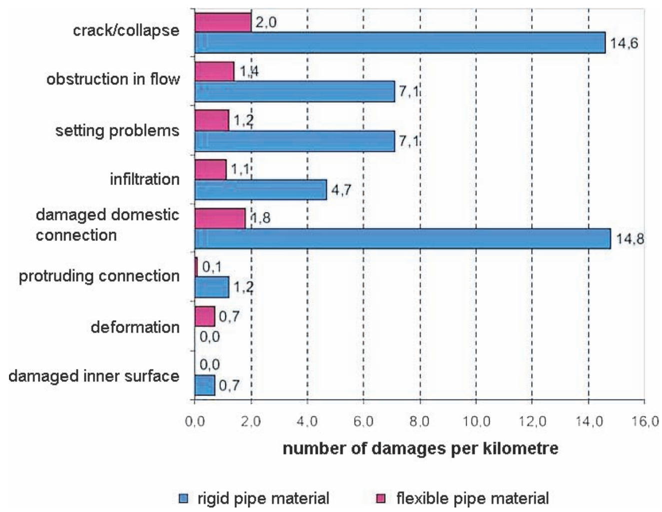


Fig. 2: Damage ratios (number of damages per sewer kilometre) of bending-resistant and flexible pipe materials in public sewer systems (2006)

1,700 km in the nominal pipe widths of < DN800 were summarised, e.g., by Prof. Dr.-Ing. Stein & Partner, S&P Bochum [2]. The fault coding corresponds to EN13508-2 [3]. Figure 2 shows the damage ratios for Germany determined here with regard to the ratio between inflexible and flexible piping systems. The clearly increased damage ratios of the criteria "broken pipe" as typical failure type of inflexible, brittle materials as well as "joining technology" are striking.

Sewer piping systems must be leak-tight such that any exfiltration of sewage water into the soil and groundwater as well as infiltration of pressing groundwater into the network are prevented. Infiltration of water may result in an overload of the system capacities, above all of the sewage treatment plants. Related to this are the risks of flooding as well as high additional costs for transport and sewage water purification because of the larger volume of sewage water. Back-washes of the bedding area are caused by infiltration and thus negatively influence the bedding, i.e. pipe statics. As a consequence, the piping system is increasingly subjected to damages. Cracks, fractures, and splintering typically occur in sewer pipings made of brittle pipe materials when subjected to overload. This may result in the collapse of the sewer.

Brittle fractures given point or line load do not occur in flexible pipes, e.g. made of polyethylene. The deformation of the flexible pipe cross-section results in a deflection or diversion of the resulting forces in the ground and thus to a self-stabilisation of the ground, the so-called tunnel effect. Thanks to the flexibility of the material, even larger deformations are withstood. International or national regulations, e.g. DIN EN 1295 [4], ATV-DVWK-A127 [5], serve the structural analysis and limit the permissible deformation of the sewage pipe.

As experience shows, settlements are completed at least after six months. The deformations caused by settlement occurring in proper installation have verifiably no long-term effects on the static bearing capacity, the function or life of the piping system.

Plastic pipes for sewer construction

Pipes made of PVC (polyvinyl chloride), PP (polypropylene) and PE (polyethylene) are used for sewage pipes. The joining technology for PVC and PP pipes is based on elastomer-sealed slip-on couplers. The material polyethylene is mainly fused which results in a material-homogeneous joint which requires no additional sealing elements. Fused polyethylene pipes facilitate the construction and operation of a very robust and durable, permanently sealed and long-lasting sewer piping system.

The material polyethylene

PE pipes have been in use for more than 50 years in domestic water supply. With the introduction of polyethylene of the third generation – PE 100 –, the acceptance of the material in water distribution also increased for larger dimensions thanks to the higher mechanical load-bearing capability and strength. In gas distribution, PE piping systems have already been used since mid-70s and today are the standard pipe material. PE80 and PE100 pipes have been used for years with excellent experience above all in the area of pressure drainage and increasingly in sewer systems.

Further optimisations of the material resulted in an improved toughness resistance to notches. Pipes with RC labelling are specifically recommended for sand bed-free installation or use in trenchless installations.

The easy installation, durability and the related economy of PE pipings open up a broad range of use in utility line construction. Apart from the conventional installation method using open trenches, polyethylene pipes are excellently suited for modern, trenchless installation methods, such as e.g. burst lining, ploughing or horizontal directional drilling.

Figure 3 shows the typical situation of the underground sewer infrastructure with inspection chamber connection and domestic sewer system as well as gas and water distribution systems.

2 What does the use of a fused PE sewer piping system mean for the operator?

- Flexible piping absorb both static and dynamic loads from the installation situation. The PE sewer remains functional where brittle materials sensitive to fractures are failing because of point or line loads.
- A homogeneous material bond between pipe and fitting is obtained thanks to the electrofusion welding. As compared to conventional slip-on coupler piping systems, the fused piping system does no longer consist of individual components but of one single homogeneous pipe section.
- The joining area is level, has a hydraulically optimal smooth surface, without socket gap, without beed and misalignment. Draining is not obstructed, deposits, obstructions and malfunctions in the sewer are avoided from the beginning (Figs. 4,5).
- Domestic sewer lines are fused on using sewage saddle fittings and are thus homogeneously jointed with the sewage main.
- The surface of PE pipes is extremely abrasion-resistant to bedload movements from the substances in the sewage water. This property has been impressively proven by the "Darmstadt method". PE pipes are thus, for example, also used in gravel plants to transport sharp-edged, hard solids, with considerably longer lifetime compared to other pipe materials. The smooth surface at the same time prevents the formation of deposits and incrustations.
- The material PE is characterised by its insensitivity to corrosion and by a high resistance to chemically aggressive transported media.
- Pipe lengths up to 20m for PE pipes require fewer joints and thus increase the position reliability of the piping. Because of the low weight, large pipe lengths can be handled easily. In contrast, the standard length of stoneware or concrete pipes is often only 2.5m because of the high weight but also because of the production technology.

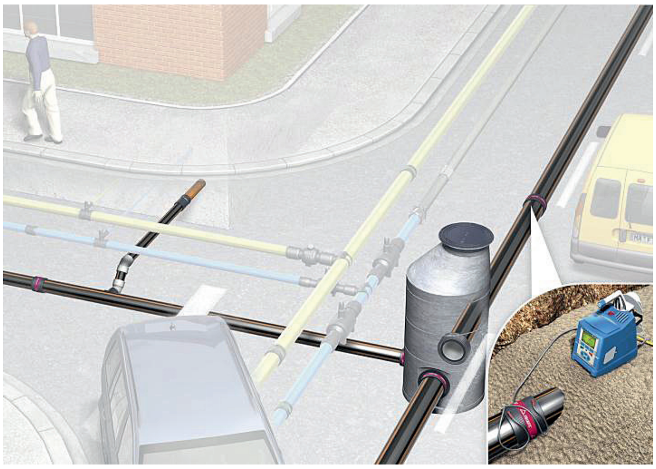


Fig. 3: Sewer infrastructure with PE pipes

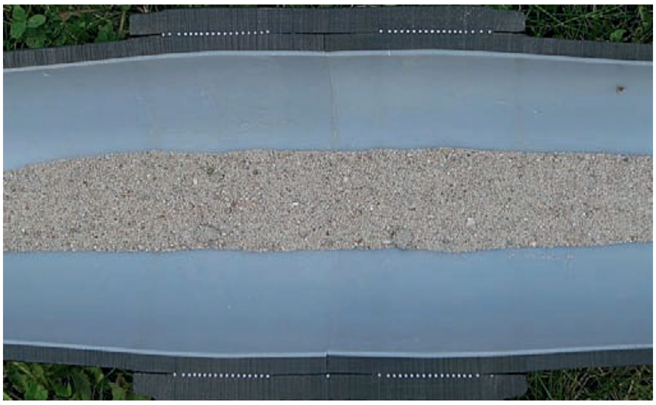


Fig. 4: Theory: Section through an electrofused pipe joint: No obstruction of the draining, hydraulically smooth channel in the joint area

Fig. 5: Reality: Camera inspection of the sewer: hydraulically smooth pipe joint

Fig. 6: PE pipe, joining method: electrofusion welding, coupler and electrofusion unit

- In case of electrofusion welding, the pipe joint in a sense conspicuous as "disturbance" exceeds the strength of the pipe. In reality this means:
- The fusion joint is resistant to root penetration. Recent findings have shown that the mechanisms of root penetration are not based on the presence of water in the piping, also not in case of leak-tight pipe joints, but on the preferred growth direction of the root in the area of the pipe bedding. The sand bedding offers less resistance to root growth than the natural ground [6, 7]. Following the pipe, the shoot sooner or later encounters a socket. In case of electrofused joints, roots have no further opportunity to grow, even not in the area of the joint, and the shoot dies for lack of nutrients.
- The joint is tension-proof, normally even unbreakable. The mechanical load capacity of the electrofusion joint is often higher than that of the pipe. PE piping systems are specifically recommended in mining subsidence areas or in regions subject to earthquake hazards.
- The joining area of the fusion coupler has a significantly higher ring stiffness than the pipe because the pipe wall thickness in the critical joining area is almost doubled. Nev-

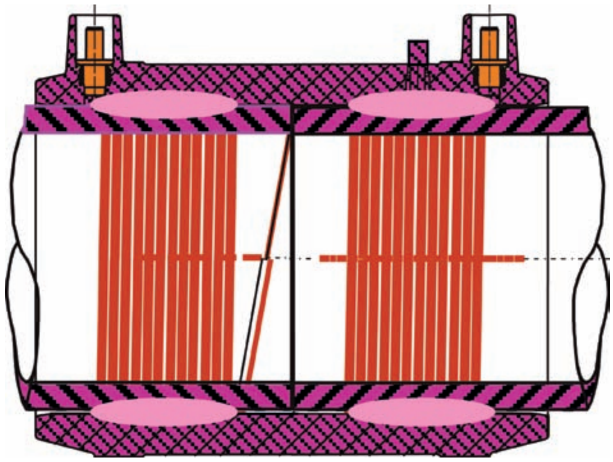


Fig. 7: Principle of electrofusion

ertheless, the joint is uniformly deformed given corresponding force application.

- Connections of lateral sewage pipes are homogeneously connected to the sewage main: no elastomeric sealing required, verifiably tight against internal and external pressures, expected lifetime same as pipe.

The electrofusion welding

For water pressure pipes with a maximum operating pressure of 16 (25) bar, axial pipe joints are made by electrofusion from d 20mm up to presently d 1200mm. Figure 6 shows a typical installation situation. For non pressure applications, there is a system of fittings in the dimension range of d 110 to d 630 mm matched to the specific requirements. These fittings in PE100, SDR17 are suitable for unpressurised operated gravity sewers made of HD-PE as well as for pressurised pipe systems up to a maximum operation pressure of 10 bars.

In addition to the line installation, electrofusion welding is a very well-suited process for repairs in the pipeline and for work in places were space is at a premium, e.g. in small trenches or pipeline junctions.

How it works (Fig. 7)

The joining areas – the external pipe surface and the inner surface of the coupler – are heated to fusion temperature with heating wires integrated in the fitting by applying electric current. During this process, melt is applied by both component parts. Having cooled, an unbreakable, homogeneous joint exists. The decisive parameters for the fusion are melt temperature and fusion time as well as melt pressure.

The parameters “temperature” and “time” are read via a bar code affixed at the fitting and automatically set by the fusion unit. The required fusion pressure results from the volume increase of the polyethylene melt.

An optimal heat transfer is obtained by the exposed heating coils [8]. The energy is thus directly transferred to the pipe surface by convection and heat radiation.

3 The PE sewer piping system

PE sewer pipes are often equipped with a bright interior coat (Figures 4, 5) to improve sewer inspection by camera. The dimensioning is typically made in SDR17.6 with a view to the pipe statics. Within the system, the pipe and suitable connectors and fittings for lateral connections are required (Figure 8).

Fig. 8: The FRIAFIT® sewage system for pipes made of HD-PE

Fig. 9: Test of an inspection chamber connection d630

Thanks to the homogeneous, friction-locked and permanently tight joint, the sewage system can also be used as single PE pipe system in water catchment areas (protection area II). The high resilience of the material, together with the friction-locked electrofusion joint, also enables it to be used in land subsidence areas.

3.1 Man whole connection

Special demands are made on the man whole connection:

- Settlement of the man whole results in bending and shear stresses which concentrate here
- The deflection capability of the connection is required by standards
- Tensile loads at the man whole base should be avoided
- Leak-tightness of the connections, also with regard to pressing groundwater
- Different material properties of concrete and PE must be considered in the design.

Figure 9 shows a test to prove the deflection capability and leak-tightness of the inspection chamber connection area of the dimension d630 under extreme conditions. The inspection chamber is filled with water. No leakage occurred during a deflection by 4° in the course of the test period of 24 hours.

Fig. 10: The undercut anchoring webs of the inspection chamber lining ASF provide a strong and tight connection to the concrete.

Fig. 11: Connection of PE pipes to a concrete man whole base with sewage inspection chamber lining ASF and insert sleeve AEM

Fig. 12: Camera inspection in the area of the man whole connection and transition from clinker-clad channel to PE pipe

Fig. 13: Domestic sewer pipes are connected using the sewage saddle ASA-TL, in this case in connection with sewage elbows ABMS d160

Inspection chamber lining

The inspection chamber lining ASF is connected to the man whole base by the anchoring web with T profile (Figure 11). Typically, the inspection chamber lining is vibration filled into the concrete during production. The webs engaged behind guarantee a tight grip in the concrete and reliable leak-tightness of the joining area. In order to obtain levelness in the channel, it is of importance that the pipe wall thickness of the selected PE pipe as well as the wall thickness of the sewage insert sleeve are considered when designing the channel of the inspection chamber base.

Sewage insert sleeve

The sewage insert sleeve AEM (Figure 11) is fused onto the PE sewer pipe. The interface to the man whole is made in an articulated way using a push-fit connection. Temperature fluctuations, e.g. during the installation of the pipes, may result in high tensile forces because of the PE thermal expansion coefficient. These forces concentrate in the inspection chamber connection. The connection is not made in a friction-locked way but by push-fit connection to prevent these forces. The flexibility of the connection prevents any possible consequential damages. The articulating link is sealed by two elastomeric sealing rings inserted in separate beads. Additional reliability is offered by a third, water-swellable sealing ring: If in contact with water, the volume of the swellable ring increases manifold and thus reliably seals off the inspection chamber connection to the surrounding ground.

Figure 12 shows such a level transition area between inspection chamber and pipe during a camera inspection.

3.2 Connection of domestic sewer systems

The sewage saddle ASA-TL (Figure 13) facilitates the connection of the lateral PE domestic sewer pipe d160/DN150 to the PE sewer in the dimensions d200 to d630. The joint – for saddle and domestic sewer – is made by electrofusion. The domestic sewer spigot is already designed as electrofusion coupler and thus facilitates the direct connection without interfering

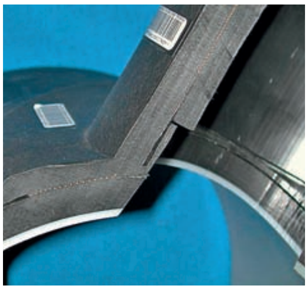


Fig. 14: Sectional model of the sewage saddle with the joints saddle-pipe and outlet-domestic sewer

Fig. 15: View into the sewage pipe: smooth, displacement-free inlets, good inspection capability of the pipes thanks to bright interior coat

displacement or drain obstructions. A separation of the piping for subsequent connections or even for renovation work, e.g. burst lining, is no longer needed.

Figure 14 shows a cross-section through the fusion joints of the sewage saddle ASA to the pipe and the domestic sewer. The sewage saddle was assembled using a combined clamping and tapping unit. The system is designed such that after tapping no protrusion or obstacle constricts the free cross-section DN 150 in the drainage area. The connection of the sewage saddle ASA is without displacement and interfering drain obstructions (Figure 15).

Leakage test for pressing groundwater

DIN 4060 [9] requires that joints of buried sewers, pipes and inspection chambers must be permanently leak-tight at an internal and external pressure of 0 to 0.5 bar. A hands-on testing of the joints under external pressure – like in case of surrounding groundwater – is typically not performed.

At the large-scale testing facility of IKT – Institute for Underground Infrastructure in Gelsenkirchen – domestic sewers were installed at a PE sewer pipe d355 with FRIAFIT sewage saddles ASA-TL 355/160. The proof of the leak-tightness was carried out at four FRIAFIT sewage saddles ASA-TL. After the successful internal pressure test according to DIN EN 1610, the system was buried under hands-on condition with a depth of cover of 5.5m.

The test for external pressure was made one year later. The test facility was flooded to simulate a "groundwater level" of 5.5m. The resulting external pressure of 0.55 bar at the joints was maintained throughout 120 hours.

The test period of 120 hours having elapsed, no penetrating water was detected and the leak-tightness of the FRIAFIT sewage saddles ASA-TL was confirmed [10].

3.3 Fittings

Sewage elbows ABM and ABMS

The sewage elbow ABM with coupler on both ends permits a change of direction with minimum footprint. The elbows d160 in 15, 30, and 45° are hydraulically optimised and offer a level passage when pipes SDR 17/17.6 are used. The type with bright coat facilitates an optimal view during camera inspection.

Fig. 16: Detail of the test set-up with four FRIAFIT sewage saddles before burying

The sewage elbow ABMS with coupler/spigot end can be directly fused with the spigot end to the outlet of the sewage saddle ASA-TL (Figure 13).

Material transitions PE – PVC/PP/stoneware

Connecting spigots UKG, transition coupler AMKG (Fig. 17) and sewage saddle ASA-TL/KG facilitate the direct transition to domestic sewer pipes made, e.g., of PVC or PP. The slip-on coupler seals off with a lip-sealing ring. The joint is made level, without interfering displacement.

Material transition PE – stoneware USTZ

Because of the considerable wall thickness difference between stoneware and PE pipe, a new fitting was specifically developed for this material transition. This facilitates direct connection without any further fittings.

4 Conclusion

The use of polyethylene in piping construction has stood the test of time already for five decades in the pressure piping systems for gas and water supply. Because of the advantages PE pipes offer in installation, operation and also from economic points of view, they are also increasingly replacing conventional pipe materials in sewage applications. PE piping systems for non pres-

Fig. 17: Transition Coupler AMKG with integrated slip-on coupler for the direct connection of a PE-pipe with a PVC/PP pipe

sure gravity appication offer an intelligent response to the urgent issues regarding the required damage remedies in the sewer and above all regarding future prevention of damages.

Electrofusion joints correspond to the state-of-the-art in PE piping construction. Processes and fittings have proven themselves in practice and could establish themselves because of the reliability a homogeneous material connection offers, the easy handling as well as the processing.

A broad fitting range offers the user problem solutions for almost any needs and all installation situations seen in practice. The sewage saddle for domestic sewers facilitates the consequent implementation of a comprehensive homogeneous and fused drainage network.

Literature

[1] IKT Product Test – House service spigots – June 2002

[2] Prof. Dr.-Ing. Stein & Partner, Beratende Ingenieure(S&P), European study of the performances of various pipe systems, respectively pipe materials for municipal sewage systems under special consideration of ecological range of effects during the service life.

[3] EN 13 508-2: Conditions of drain and sewer systems outside buildings – Part 2: Visual inspection coding system

[4] DIN EN 1295-1: Structural design of buried pipelines under various conditions of loading

[5] ATV-DVWK-A 127: Structural design of sewers and drain pipes

[6] "Kanal voll: Wenn Bäume in Rohren Wurzeln schlagen", Prof. Dr. Stützel, Faculty of Biology – Ruhr-University of Bochum, Dr. Bosseler, IKT, RUBIN 1/03

[7] Root penetration: *www.ikt.de/down/f0108kurzbericht.pdf*

[8] „Verbindungstechnik für PE-Rohre", Konstruktive Merkmale für eine höhere Verarbeitungssicherheit von Heizwendelschweißformstücken, Dipl.-Ing. Robert Eckert, 3R international, March/April 2003, Vulkan-Verlag GmbH, Essen

[9] DIN 4060: Joints of sewer and drain pipes with elastomeric seals – Requirements and testing on joints with elastomeric seals

[10] IKT, test order no.: P02609, designation of the test order: Testing of FRIAFIT sewage saddles for leak-tightness at external water pressure loads of 0.55bar.

Further references

- „Gehört dem Kunststoff die Zukunft?" – Rohrmaterialien im Vergleich, Interview mit Dipl.-Ing. Manfred Fiedler, wwt, 10-11/2003
- „FRIAFIT-Abwassersystem für Freispiegelleitungen: Die sichere Verbindungstechnik für Schmutz- und Mischwasserrohrleitungen aus PE-HD, Montageanleitung
- Rohrsysteme aus PE100 / Heiner Brömstrup (Hrsg.) – Essen: Vulkan Verlag, 2.Aufl. 2004
- Kunststoffrohrsysteme in der Abwassertechnik, Kunststoffrohrverband e.V. Bonn (Hrsg.) – Essen: Vulkan-Verlag, 2003

Author

Dipl.-Ing. Robert Eckert
FRIATEC Aktiengesellschaft
Steinzeugstraße 50
68229 Mannheim, Germany

e-mail: robert.eckert@friatec.de

KA

Pricing Policies for Sustainable Water Services

Pricing of environmental and resources costs of water services

Werner Wahliß (Munich, Germany)

Abstract

The EU Water Framework Directive (WFD) has set up two economic principles for the pricing of water services like water supply and wastewater disposal: All prices shall be based on full cost recovery and the water-pricing policy shall provide adequate incentives to use water resources efficiently and thereby contribute to the environmental objectives of the directive [1]. In this paper the focus is on practical applications and limitations of these pricing principles.

Pricing of water services

Water prices typically (and for good reasons) do not result from competition on a free market but are regulated to a large extent. In Germany e. g. law has stipulated the principle of cost recovery for public water services for a long time. But Article 9 WFD now specifies that the price of a water service has to account for the principle of cost recovery, including "environmental and resource costs" (ERC) and regarding the "polluter pays principle". Following the theory of opportunity costs this "full costs approach" includes external costs (externalities) in terms of unintended damage to the environment or other users, which in turn has an impact on public welfare. In the context of the WFD the due consideration of ERC in the price of water services is fundamental, because this is in fact the link between economic and environmental efficiency. Yet accounting for the costs of externalities is challenging. The practical questions are, how to designate and internalise these costs and to what extent this is beneficial for the environmental objectives of the WFD.

Conflicting goals in water pricing

Prices of water services are meaningful for social welfare and arouse a high degree of public interest. For this reason pricing policy usually has to reflect social, economic and environmental objectives. Article 9 (1) WFD allows accounting for these issues as well as for geographical and climatic conditions. The WFD considers the price of water primarily as a tool for demand management so that there is an incentive to meet the environmental objectives. Hence the price of a water service also has to secure sufficient revenues for the service provider. And from the economic point of view the price shall contribute to economic efficiency or making the best use of the water resources.

Setting a price for water services therefore often requires trade-offs between conflicting goals. A pragmatic approach for balancing different goals is a two-part tariff combining a fixed and a volumetric (per-unit) charge, so that fixed costs (e. g. for infrastructure) and volume-related costs (e. g. for operation) could be incorporated. In the same way costs of externalities may be included as a fixed or a volumetric charge. Water services usually show a high ratio of fixed costs, which should be covered by a fixed charge so as to secure sufficient and steady revenues for the water utilities. However the volume-related part of a tariff should dominate in order to send signals to the user to use water efficiently.

Incentives for an efficient use of water resources can be given effectively by an appropriate tariff structure especially by the increment of the per-unit price. A uniform tariff means that the per-unit price is fixed regardless of the total amount of water or effluent delivered. An increasing tariff may be suitable for social reasons, e. g. in order to unburden low-income classes, but also for countries with water scarcity. A decreasing tariff, where the per-unit price falls with the total volume of water, is in favour of large consumers – for example industry or agriculture – and may be considered for economic reasons. Yet this tariff structure is inconsistent with the objective of preserving water resources.

Charging for externalities of water services

The provision of water services may cause positive and negative externalities. Impounding a river for the extraction of water e. g. may disrupt fish migration and spawning. This again may have direct impact on anglers and commercial fishing and indirect long-term impact on social welfare by the loss of biodiversity and ecosystem services. On the other hand an impounded river may be beneficial for recreational boaters, mitigate floods and provide habitats for breeding and migrating birds. However typically negative externalities outweigh the positive ones and the WFD is focused on un-prized environmental and resource costs of water services because this may lead to over-use or overly pollute water.

Let us first have a look at resources costs. According to the economic theory of opportunity costs [2] the price for water services should cover not only the costs for the processing of water (e. g. for abstraction, storage, treatment, transport) but also the social value of natural water. This value is a consequence of water scarcity depending on the relation of demand and availability. Consequently in water-rich regions like alpine uplands this value tends to zero.

In general including minor resource costs into the price of water is not likely to have a significant effect on the users. Therefore externality charges are often not aligned with calculated opportunity costs. Instead of that it is argued for that a charge must be high enough to cause a steering effect by arousing a response from the water users [3]. The appropriate basis for the design of such a charge is the price elasticity of demand. In reality the charges are more or less the result of a political agreement. However in this case, a clear and consistent pricing aim and strategy is necessary, because water management is not about reducing the use of water "at any price", but about optimal allocation of the water resources for the society. Increasing the price of water services arbitrarily may impair economic development and the efficiency of public water services. It may trigger second-best solutions like replacing one water resource by another or substituting high quality by low quality water, entailing hygienic and environmental problems.

Charging for environmental costs is suitable if volumes of water can be used as a measure for the external impact, e. g. the volume of water abstracted from an aquifer or the volume of wastewater discharge into a river. In Germany e. g. two important volume-related charges have been introduced by law: A charge for waste water discharge is obligatory by federal law and regional charges for drinking water abstraction are established by state law. It is more difficult to figure out prices for non-volume-related externalities, as is often the case with water quality problems from diffuse pollution. If an impact on water quality is hard to trace back to its origin, such as sedimentation, it is difficult to employ a pricing strategy. Nitrate pollution of groundwater from agriculture e. g. is mainly not caused by water use but by land use. Here instead of water pricing another approach is required, which addresses the driving forces behind the pollution of water, like the use or production of fertilizers.

Another point is that an externality charge is more suitable for protecting the environment against incremental degradation caused by the use of water, like wastewater discharge in rivers. But if there is a risk of irreversible damage to valuable or protected nature by the use of water resources other instruments must be applied. Regulations that clearly limit the abstraction of water are essential.

Direct and indirect pricing of externalities

In principle direct and indirect mechanisms are available for pricing externalities [4]. Direct pricing is an effective tool when dealing with volume-related externalities. An alternative concept, especially for non-volume-related externalities, is indirect pricing by taxes, subsidies, concessions or property rights as well as offsetting or incentive policies. Another obstacle for direct pricing is when the polluter pays principle is difficult to apply or only at high transaction costs e. g. for monitoring and controlling. In general *direct* pricing of externalities seems to be a *more/less* reasonable instrument if

- externalities *are/are not* related to volumes of used water
- water resources are *scarce/abundant*
- the pressure on water is *quantitative and from point sources/qualitative and diffuse*
- protection of water resources *is not/is* secured by law and other regulations
- the transaction costs for the internalisation of ERC or the PPP are *low/high*
- the level of efficiency in water use of households, industry and agriculture is *low/high*
- the polluter (user) pays principle *is/is not* accepted by the users (polluters)
- the users of water services *are/are not* likely to respond to price changes
- irreparable damage of valuable (protected) environment *is not/is* at stake
- metering of water services *is/is not* widely spread.

Regulations and technology

Pricing is a prime tool for managing water scarcity by reducing demand. It can also be useful for controlling environmental externalities but there are other policy options available for managing externalities like regulations of water use and the deployment of technologies for an efficient use of water services. In Germany e. g. public law on water and environmental aims at avoiding, minimizing and compensating environmental externalities. Legal permits for water uses impose conditions, bans and rules for the use and the costs have to be borne by the user. The concept is based on proportionality in order to achieve an environmentally, economically and socially acceptable level of externalities rather than eliminating them completely. In this context water pricing of externalities is used as a supportive instrument.

Metering of water is a precondition for applying the polluter (or user) pays principle and for a disaggregation of costs between sectors of use like households, industry and agriculture, as is requested by Article 9 (1) WFD. Other important technological instruments are devices for water saving and technical standards for an efficient use of water. Prevention or repair of leakage from the piping for drinking water and sewage may reduce environmental damage and economic losses. The costs of these precautionary measures in operation and maintenance are internalized costs for avoided externalities.

Concluding remarks

The WFD introduces the principle of full cost recovery for water services, including environmental and resource costs in order to support the environmental objectives of the directive. Hence not all externalities are suitable for quantifying and direct pricing of water services. And not all costs of externalities do really matter for the use of water services. Furthermore pricing policy has to deal with many – economic, ecological and social – conflicting goals. Therefore pricing policies are only auxiliary instruments for reducing environmental and resources externalities, which can be employed to back up sound regulations by law and efficient technologies for water-use. For water management a portfolio of these instruments may be the best option.

References

[1] European Communities: Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Bruxelles, 2000

[2] Griffin, R. C.: *Water Resource Economics*, London, MIT Press, 2006

[3] Gawel, E.: Zur Lenkungswirkung von Wasserentnahmeentgelten, Teil 1–3, *KA Abwasser und Abfall* 1/2012, 46–51, 3/2012, 225–233, 4/2012, 343–347

[4] Hatton MacDonald, Darla: The Economics of Water: Taking Full Account of First Use, Reuse and Return tot he Environment, CSIRO Land and Water Client Report for the AWCRRP, Adelaide SA, March 2004

Author

Dr.-Ing. Werner Wahliß
Bayerisches Staatsministerium für Umwelt und Gesundheit
Rosenkavalierplatz 2, 81925 München

e-mail: werner.wahliss@stmug.bayern.de

Concerted Action – the GWP Regional Section Croatia

Stefan Girod (Berlin, Germany)

The regional section Croatia within German Water Partnership is a very active working group with excellent connections. It was among the original 15 regional sections founded 2009. One of its main achievements so far surely is the foundation of the Training and Competence Centre Karlovac.

In 2009 German Water Partnership has founded subdivisions that are concentrating on the markets of certain target countries or regions, the so called regional sections. Their members are companies, associations and research institutes who are already doing business in the target country or region or are planning to enter the market. At the moment there are 17 such regional sections with focus countries and regions all over the world. During the last years they have kicked off projects and initiatives of various kinds, always working together with local partners. Two of the main projects of the regional section Croatia are the Training and Competence Centre Karlovac (TCC Karlovac), an educational institution for people working in the water branch, and the construction of a wastewater treatment plant in Ogulin.

Preparing to join the EU

With the joining the EU scheduled for July 2013 Croatia is facing great challenges in meeting the requirements of the Urban Wastewater Treatment (UWWT) Directive. There is a great deal to catch up on in wastewater treatment starting with establishing the necessary infrastructure. The proper ministry estimates the investment needed to implement the national water strategy at roughly 4.5 billion EUR. At the same time personnel has to be trained in both, operation and maintenance as well as

Fig. 1: Capacity building in Karlovac: train the trainers

Fig. 2: Water and wastewater treatment plant Ogulin under construction

technical management. The regional section Croatia and the companies involved in the project are available to share their know-how and experience.

Capacity building in Karlovac

The regional section Croatia has been actively involved in the creation of the TCC Karlovac right from the beginning in 2010. It developed a concept for a pilot phase of twelve months. „The upcoming joining of the EU requires modernisation and expansion of the old or non-existent infrastructure to meet EU standards, especially on the field of wastewater management.“, Dr. Heike Burghard, head of the regional section Croatia, explains. „In order to operate all these new wastewater treatment plants, you need qualified personnel and that is where our concept fits in. We will train staff for operation and maintenance as well as members of the technical management.“

The Croatian Ministry for Regional Development, Forestry and Water Management strongly supported the idea and agreed on co-funding with the German Ministry for the Environment. The funding was granted in the summer of 2011. The pilot phase is currently underway and will be completed in September 2012 (Fig. 1). The main objective of the pilot phase is to establish an organisational and institutional framework to afterwards determine who will be the responsible body in the future. To learn more about the TCC visit *www.tcc-karlovac.org*.

Wastewater treatment in Ogulin

But members of German Water Parnership not only help to advance Capacity Development. They also take part in tenders and have won many of them – whether individually, as tender groups or in cooperation with local companies, like in the case of the wastewater treatment plant in Ogulin, Croatia. Here, HST Meschede (Germany) together with its Croatian partner Hidroelektra Niskogradja d.d. obtained the contract for the turnkey construction of the plant.

One of the main challenges of the project had already to be mastered during the tender phase: according to the planning of the city of Ogulin the wastewater treatment plant is ultimately intended for 15,000 population equivalent (PE) (Fig. 2). But by estimation this size will only be needed in 15 years. Therefore the construction of the wastewater treatment plant will be divided into two phases: in the first phase the plant is constructed for 7,500 PE, later it will be extended for 15,000 PE. Thus the applicants for the tender had to present a solution that allows extending the plant to double capacity as easy as possible while keeping the costs of the first phase in reasonable bounds.

HST and Hidroelektra Niskogradja presented a convincing solution with modern measurement technology and dynamic process management. Thus the city of Ogulin is getting a wastewater treatment plant that lies well above international standards and makes the city well prepared for Croatia's joining the EU in 2013.

Networking is the base for success

Since its foundation in 2008, German Water Partnership has created a strong global network with more than 330 members, working in all fields of water management. It looks back on a long series of achievements of which the regional section Croatia is only one example. Together its members are able to find custom-made and sustainable solutions to all kinds of challenges of water management. German Water Partnership uses its strength and its influence also on behalf of the Millennium Development Goals.

Author

Dipl.-Ing. Stefan Girod
German Water Partnership
Reinhardtstraße 32, 10117 Berlin

e-mail: info@germanwaterpartnership.de

KA

Training Curriculum Development for WWTPs Operators and Managers in Bangladesh

A project of GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) in cooperation with IKEA

Rainer Abendt (Nuremberg, Germany), Juergen Hannak (Colombo, Sri Lanka) and Elke Shrestha (Dhaka, Bangladesh)

Environmental compliance is increasingly becoming a decision factor for industrial enterprises to stay sustainable and to expand its business activities. This applies even more for enterprises producing for export. Furthermore, the government of Bangladesh puts increasing pressure on industries that are polluting water, air and soil to abide by environmental laws and legislations. It is a known fact that there is a need for industries to adopt environmentally friendly practices but only a small number of industries so far are conscientious on the impact they have on the environment.

While it is easy to blame the private sector in being disengaged in the battle against environmental pollution, there is another factor which aggravates the situation: It is hard to find employees that dispose of the respective knowledge, information and skills. There is a dearth of environmental specialists in the market and as a result of that, industries employ staff in key technical positions that have little or no expertise in their field of work.

As a response to this, GIZ PSES in cooperation with IKEA, decided to launch an initiative to develop technical expertise in the area of waste water management, namely, the management, operation and design of effluent treatment plants.

The German Association for Water Management, Wastewater and Waste (DWA) was invited into the joint initiative of GIZ PSES and IKEA on the development and implementation of a program to qualify managers and operators of effluent treatment plants in Bangladesh. As an international training partner, DWA is expected to contribute to the joint initiative with its experience in vocational training in the area of waste water treatment and to assist the local training partners in setting up a training program for ETP Managers and ETP Operators based on the German training model and approaches. DWA deputed Dr. Rainer Abendt as its representative for the preparatory mission, which took place during the period from 13 to 17 November 2011.

Main objectives of the DWA preparatory mission were

- to obtain the buy-in from industry on the training program and the proposed training approach,
- to clarify the learning subjects and expected learning outcomes of the proposed training program with the initiative's stakeholders,
- to assess the suitability of the short-listed ETPs as for on-site practical training, and
- to arrive at a working agreement with the short-listed local training partners for the development and implementation of the training program.

The „ETP Roundtable Workshop" brought together representatives from buyer, training institution and industry side, with the objectives to arrive at a common understanding of the proposed initiative by GIZ and IKEA for establishing a certified training program for the management, operation and maintenance of effluent treatment plants (ETPs) in Bangladesh, to take a decision on the further steps as well as to clarify the roles of the different stakeholders. The roundtable contributed to a better understanding of the initiative, the context and scenarios of effluent treatment requirements in Bangladesh and the contribution of adequately qualified ETP personnel to treatment performance and costs. In two working groups, lists of required learning outcomes and subjects (skills, knowledge) were finalized.

Based on walk-through visits to selected effluent treatment plants of the suppliers to IKEA and on-site discussions with the company management and ETP personnel the suitability of these ETPs as potential training sites were assessed. All ETPs visited were found to be suitable for the various types of practical on-site training. The visits also helped to further ascertain specific training needs.

Three short-listed training institutions were visited to further assess their suitability as local training partners as well as to clarify expectations and possible modes of cooperation between GIZ/IKEA, industry and training institutions. The specific needs with regard to instruments and equipment for proposed training were identified.

In the next phase, the trainings contents will be discussed between DWA and the training institutions and a time schedule and supporting documentation will be identified and elaborated. The training concepts for both the personnel and the managers of the treatment plants shall be communicated to plant managers and IKEA and the relevant authorities in Bangladesh.

Certificates provided by German and Bangladesh educational institutions shall be prepared and submitted to evidence training results and act as a standard and example for ETP personnel.

The implementation, performance and evaluation of the trainings will be done in a third step. Details of staff members to be trained as trainers and their training-of-trainers will be worked out and results are aimed to be transferred to other plants and industries as well.

Representatives of training institutions, DWA
GIZ in a workshop in November 2011 in Dhaka KA

Cost-Benefit Analysis – User‘s Project Appraisal Manual

A project sponsored by DBU (German Environmental Foundation)

Reinhard F. Schmidtke (Planegg, Germany) and Gabriele Martens (Hennef, Germany)

DWA in cooperation with the water and wastewater associations in Bulgaria, Hungary, Romania and Slovakia

The User's Project Appraisal Manual is intended to support the relevant institutions in Bulgaria, Hungary, Romania, and Slovakia to realize and introduce a work instruction for the consideration of economic aspects of infrastructure measures for water supply and wastewater disposal in rural areas. The infrastructures in rural areas differ in many cases from those in urban areas ruled by the European Commission Criteria for CBA-Guidance. For the infrastructure in rural areas there is a need for relevant calculation instruments considering economic aspects. The methodological equipment for the project planning is the Dynamic Cost-Comparison which is applied in Germany as a generally accepted standard since years. In addition, the implementation of the User's Manual shall supply the data bases for applications for subsidies from the EU to perform economic and financial analyses. The Manual shall enable the applicants to achieve the most cost-efficient measure out of the decision-relevant options in solving the planning tasks in water supply and wastewater disposal. That means, the crucial point is a sophisticated method for handling the so-called selection problem. Therefore not only the economic evaluation of the options has to be taken into account, but the complete planning procedure. Only by takingin the intended objectives of the system and the options tuned to these may lead to a sound result in view of economic efficiency.

Efficient and economic proceedings in planning, construction, operation and maintenance of infrastructure water supply and wastewater disposal in rural areas demand great economic consciousness and a change in attitudes.

Project description

The project was divided into two parts. In Part 1, a User's Manual in English language was worked out during a one week workshop. In Part 2, DWA supported application tests to pilot projects and, where necessary, country-specific modifications and the communication and knowledge transfer in the 4 countries to instructors and appliers. In addition, a Train-the-Trainer workshop prepared the participants to communicate and implement the Manual. The English manual version was therefore translated into the four languages and served as the bases for the national workshops.

Result of the project

The "national workshops" in the involved countries were partly accompanied by the seminar director. A brief demonstration is the workshop in Sofia: it took place in October 2011 and is described by the Bulgarian association as follows:

The Bulgarian Water Association hosted the first certificate course on dynamic costs comparison methods for water investment projects held in Rodina Hotel, Sofia, Bulgaria on 6th and 7th October, 2011. The course was one of the main results after the 2 years project, led by DWA and financed by the German

Environmental Foundation (DBU). The course put together 17 designers, water engineers and financial analyzers. The key aspects were presented by the special guest of the event – Prof. Reinhard Schmidtke. For the first time in Bulgaria the adopted version of this methodology has been announced; it is going to be used for the implementation of major water investment project in the next year.

The course was officially opened by the Vice President of BWA – Mr. Ivan Ivanov and Mr. Marian Buhov, Director of Water and Sewerage Regulatory and Control Division at the State Energy and Water Regulatory Commission.

The course was led by three trainers: Ms. Albena Vatralova, MEng, MEcon, Department of Water Management and Usage at NIMH-BAS, Ms Kalina Kalcheva-Lapova, MEng, Aquapartner Ltd. and Mr. Teodor Daskalov, MEcon, Utilities Services Ltd., all of them participants in the meetings for the adaptation of the DWA guidelines for dynamic costs comparison methods.

After the 2-day training the participants gained knowledge about:

- investment needs and their estimation,
- how to use adaptive approaches for different projects in terms of their size and contents,
- how to calculate and analyze the problem area and compare technical solutions in terms of their financial effectiveness for long periods,
- how to use this tool to justify a project proposal applicable to different operational programs and bank institutions.

The training course was the pilot phase to test the approved methodology under Bulgarian conditions. The comments of the participants showed their satisfaction with the provided materials, proposed lectures and practical examples from the trainers.

All participants received certificates for attending the course from Prof. Roumen Arsov, President of the Bulgarian Water Association. The next course for advanced participants is planned to be held in the spring next year. KA

Young Water Professionals‘ Programme

Laura Langel (Hennef, Germany)

The first Young Water Professionals‘ Programme took place at the occasion of the “IWA World Water Congress” 2001 in Berlin. 100 young engineers from 13 countries participated. From then on the programme became a regular annual event, accompanying international fairs in Germany, such as IFAT (now IFAT ENTSORGA) and Wasser Berlin International. Every year 50 engineers at the age of 20 to 35 years participate in the programme, often they come from more than 20 countries. All in all 500 participants from more than 60 countries have attended the event.

In the one-week programme the young engineers get to know the water sector and German Know-How. They participate in seminars and symposiums, get in contact with different companies and experts and undertake technical excursions, for example to wastewater treatment plants or waterworks.

Last, but no least, this programme gives many of the Young Water Professionals the chance to build up a world-wide network with people with the same interest – water. Many of them are still in contact, most join the “DWA Young Water Professionals”-Group at Facebook.

Young Water Professionals from Bulgaria, China, Colombia, Ethiopie, Ghana, Indonesia, Kamerun, Kenya, Nepal, Mexico, Palestine, Poland, Romania, Russia, Thailand, Turkey, Uganda, USA, Usbekistan and Vietnam

Young Water Professionals in the introductory session

Young Water Professionals watching the high flood model in Cologne urban drainage

The 10th anniversary

The 10th Young Water Professionals' Programme took place in Berlin 2011. Apart from many activities during the week, the 10th anniversary was celebrated on May 2. The president of DWA, Otto Schaaf, and sponsors of the programme came together with the group of young people and jointed the anniversary party. In addition, DWA created a "Festschrift" (commemorative publication) with a review about 10 years Young Water Professionals' Programmes, including some comments from Ex-Participants. See "Festschrift" and the report of the participants of the 2011 programme under *www.dwa.de*.

Comments from Ex-Participants

Farzana Afreen (Bangladesh, YWP 2010): "It was an excellent platform for networking and for sharing views with the other water professionals"

Erni Murniati (Indonesia, YWP 2005): "The YWP gives opportunity to link between theoretical background and application, describes the technological state to date, and exchange and sharing knowledge and know-how not only with industrial perspectives but also among the participants"

Dr.-Ing. Maryna Tserashchuk (Belarus, YWP 2005 und 2006): "Last year I became a vice-chairman of the YWP-Committee of IWA that is responsible for Eastern Europe and the CIS countries. I had a great opportunity to participate in YWPs and … I have realized that networking is very important for one's career development and it has given me many opportunities."

Asst. Prof. Dr.-Ing. Panalee Chevakidagarn (Thailand, Young Water Professionals' 2001): "It was the first time for me I met a lot of people who had same ages and interests."

Young Water Professionals' Programme 2012

From 6th to 11th May 2012, the 11th Young Water Professionals' Programme will take place in Munich at the occasion of IFAT ENTSORGA. Apart from technical excursions, the EWA Symposium, a DWA Forum about "Aspect of the Water Industry" and social events, such as the IFAT ENTSORGA opening festivity, there will be the **Young Water Professionals' Lounge** as a highlight.

DWA-Junior Members and (Ex-) Participants of former Young Water Professionals' Programmes are invited to visit the Young Water Professionals' Lounge during IFAT ENTSORGA 2012. Here young people will meet and greet – relax from trade fair visits and excursions, listen to presentations and engage in experts' discussions, and exchange impressions of the fair, the events, the conferences etc. – or just small talk and network. In the afternoons, presentations of the water historic society about water history in Germany and worldwide will broaden the auditoriums' horizon. The Lounge is meeting point for international contacts. DWA Junior Members and Ex-YWP-participants may register for free access to the lounge. Registration is obligatory. Registrants will get name badges for *free entry*.

DWA-member companies are invited to send their trainees and young engineers working in the international field to get in contact with other young water experts and network and learn from others. Make early contacts with the managers of tomorrow in different countries. There is no better opportunity!

Further information

For further information, please do not hesitate to contact the author, Laura Langel:

e-mail: langel@dwa.de

Capacity Development

International Water Training – Seminars and Courses in English language

Gabriele Martens (Hennef, Germany)

Capacity development is based on individual knowledge, good organizational structures and institutional setups. DWA offers a wide range of methods and advices to improve the existing structures. Training courses in English language last five days and take place continuously in Germany.

A selection of seminar topics is described as follows:

Membrane Technology in Germany

Basic elements of membrane technology, mechanical pretreatment, implication of membrane technology, mechanical sludge dewatering, failure problems, methods for cleaning the membranes, cleaning chemicals, permeability, energy consumption-optimisation, membrane filtration in water treatment, microfiltration, ultrafiltration, nanofiltration, reverse osmosis, membrane bioreactors, including visits to different plants with wastewater treatment works, water treatment, industrial membrane plants.

This course is for engineers and managers from engineer offices and sewer network operators.

Participants from West African water authorities discuss the build-up and development of water associations

Training on membrane technology

Sewer Inspection

Execution and evaluation of sewer inspections and the production of rehabilitation concepts with emphasis on the application of the relevant EN standard specifications. The seminar places initial emphasis on an overview of the valid and applied sets of rules and standards in Germany, the applied technical standards and also the technical possibilities of a sewer inspection. The second point of the emphasis of the seminar takes into account the perspective of the attendant engineer with regards to planning, engineering supervision and monitoring and including the evaluation and production of an economic rehabilitation planning. Demonstrations of various systems of TV-inspections and monitoring are some of the practical tasks in the seminar.

Target groups are engineers and managers from engineer offices and sewer network operators.

Integrated Water Resources Management (DWA in cooperation with Cologne University of Applied Sciences – ITT)

Objective of this course is, that the concept of water resources management and its application in Germany and the EU is understood and the participants are familiar with tools to support water management, assessment, decision making and data management.

Contents of the course are: introduction to IWRM principles, water resources assessment, water uses and their related technologies, water legislation and the EU Water Framework Directive, watershed management and resource planning, transboundary watershed management: Rhine and Danube River case studies, information management and tools for IWRM, visits to watershed management institutions and companies in the region. KA

Arabic Technical Terminology Online Dictionary: Water Volume available now

The Technical Dictionary ***www.arabterm.org*** *is an online internet dictionary jointly commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Arab League Educational, Cultural and Scientific Organization (ALECSO), and carried out by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in collaboration with ALECSO's division in Rabat, the Arabization Coordination Bureau (BCA). The Goethe Institute, as a main agent, has coordinated the translation process.*

This multidisciplinary project aims at creating opportunities of knowledge transfer for key technologies that have been identified as vital with regard to more sustainable absorption within the Arab world.

Divisions, within the latter, between a rather French-speaking Western sphere and a rather English-speaking Eastern sphere, and additional mono-lingual countries with Arabic only, often block exchange of expertise within the Arab world. Experts who received their own education in a European language find difficulties, even on a purely national level, to disseminate their expertise within the classical educational framework.

The ground-breaking Arab Human Development Report 2003 pointed out that knowledge transfer cannot take place when academic and vocational students do not dispose over a command of terminological precision in their habitual language. Often, the tuition takes place in a linguistic jargon enriched with spoken dialectal Arabic mixed with English or French technical terms, while teaching manuals are in English or French only.

Screenshot of www.arabterm.org

Not exactly simple preconditions for a dictionary project

The Arab League's Educational, Cultural and Scientific Organization (ALECSO), as the political partner in this project, by way of its Arabization Coordination Bureau (BCA), plays a pivotal role with regard to this linguistic riddle. ALECSO, functioning here as a language authority, has an outreach on 22 Arab countries and guarantees, through its expert committees, for the standardized, approved, and correct terminology.

However, in order not to interfere with current linguistic realities, and to avoid linguistic impositions, local or dialectal variations of actually used vocabulary are being respected and also listed in this online dictionary.

Creative adaptations are needed for borrowings from foreign languages particularly when certain terms do not exist yet: how do you translate the English term of „hydrocyclone" (in German: Zykloneindicker) into Arabic? What does "abutment sidewall" (in German: Wehrwange) mean? Is there an accepted standard translation, which reflects the scientific aspect of the – misleadingly simple sounding – term "white water" (in German: Pflegewasser)?

These are some of the questions Arab water experts and translators are dealing with. Dr. Tarik Abdel Bary, head of the Cairo-based translation team, explains that "…terms like 'stone mesh' (in German: Drahtsenkwalze) are missing in current Arabic dictionaries, whereas they are very established in German or English ones." Thus translations of terms had to be checked, researched, updated or even newly build – in a way fitting the Arabic scientific language. "We could have translated the German word of "Kaiserstuhl" (German synonym for: Zapfenlager, in English: pivot bear) into Arabic very literally, as to make it more pictographic ('Kaiserstuhl' literally translates as 'emperor's chair')" he says. "Instead we used an Arabic term closer to the English term, and thus less pictographic. This way the Arabic term won't sound too strange to Arabic experts, especially since the *www.arabterm.org* dictionary addresses water experts of different Arabic countries."

Allowing a shortcut into the internet age

There has been a – hitherto unprecedented and unrepeated – precursor of the online dictionary project for Arabic technology, in the shape of an eighteen volumes printed dictionary by renowned Edition Leipzig from the late 1970ies. Its former editor, Dr. Anwar Abdel Wahed, was implicated in the current project as chief editor of the translation. *www.arabterm.org*, as an online dictionary, cuts short both the production process and later revisions and updates, by comparison.

www.arabterm.org is organized per industry sector and provides a generally accessible reference for six volumes. The currently launched "Water" volume was realized in cooperation with DWA, the German Association for Water, Wastewater and Waste. DWA was in charge of compiling the original German content – around 7000 water terms, along with concise and comprehensive definitions. DWA's Jordanian partner organization, the Arab Countries Water Utilities Association (ACWUA), also contributes technical drawings and pictogram content.

An outlook: further volumes for new groups of users

Further volumes are "Motor Engineering", "Renewable Energy", "Electrical Engineering", "Textile" and "Transport/Infrastructure" – all of them meant to facilitate access to updated knowledge and expertise for users in the Arab world, and for the consistent translation of textbooks, curricula, technical manuals and other specialized texts. German and Arabic stand for the direction the knowledge exchange has had, English and French are vital additions with regard to language realities within the Arab world. Additional volumes, and eventually additional languages (like e. g. Spanish) might be added later.

An interactive discussion forum offers the opportunity to exchange ideas on linguistic problem areas in the various disciplines, as well as to suggest new terms or more detailed definitions. These discussions and suggestions will provide the basis for an annual revision of the database.

www.arabterm.org's main target group is experts and translators, but also students, technical journalists, universities and industries as well as generally interested users; it is available online, free of charge.

Author

Guido Zebisch, GIZ, Project Director/Chief Consultant,
With the co-authorship of Lilly Ottens, Goethe-Institut,
translation coordinator

KA

Products and Services

TSSR-EX shaft cleaner now equipped with compressed air drive

The tried-and-tested TSSR shaft cleaning array from Hermes Technologie can now be used in hazardous areas where there is risk of explosion. Whereas the TSSR had previously been powered by a 24 volt motor, the latest development by Hermes has been to equip it with a compressed air motor. Moreover, this very easily installed cleaning array is constructed entirely of stainless steel and aluminium, and has thus been awarded ATEX certification.

The impetus for this development came from our most recent M-Coating client. The client had contracts for which he was only allowed to use explosion-protected equipment when cleaning shafts. The new TSSR-EX meets these requirements. It is also rpm-controlled and is steplessly adjustable to the diameter of the shaft.

The TSSR is normally supplied with 24 litres of water per sec at approx 400 bar pressure. Its high cleaning power was verified years ago at the Institute for Pipeline Construction (IRO – Jade University of Applied Sciences, Oldenburg, Germany).

Thanks to its explosion-protected technology, it is the only shaft cleaning equipment that can be immediately put into operation in the shaft, with very little preparation. This represents an enormous cost benefit to the job. The TSSR is both a component of the M-Coating system and an important element when cleaning shafts in preparation for an inspection, e. g. with the IBAK panoramic camera. When inspecting shafts, too, it is important that all corroded material be cleaned off before the TV survey of the substrate. Otherwise, subsequent evaluation of the photographic images is of only limited significance. How is the engineer back in the office supposed to tell whether the surface is sound or corroded, under a layer of sludge? Even low-level infiltration is difficult to spot where the surface is dirty.

Only with the TSSR is it possible to clean shafts while complying with accident prevention regulations. With this system, the operator stands outside the shaft and only has to monitor and supervise progress. He does not have to climb into the shaft with a hand-lance and clean the shaft while disregarding safety precautions.

www.hermes-technologie.de

Automated shaft coating proves its worth!

Last year, automated shaft coating (ASB) was added to the operator training course for M-Coating users, for the first time. Today, one year later, Hermes Technologie confirmed that fully automated shaft coating has proved its worth.

Under ASB, all parameters for the coating process are entered into a small computer. Taking the shaft diameter and the coating thickness into account, the required figures are read off from a table, and each value is entered into the computer. The depth of the shaft, or the length of coating to be applied, are then measured to within a centimeter by using the winch and centrifuge motor. For that, the operator lowers the centrifuge down the length of shaft to be coated. The computer makes a note of the distance and calculates from that the quantity of Ergelit required.

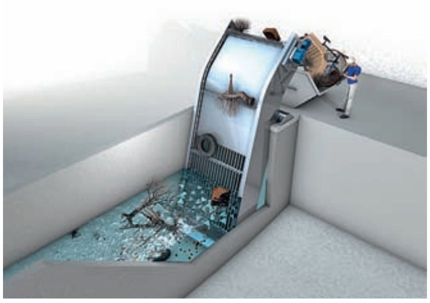
The mixer is now started up, ASB is turned on and the coating process begins. First the pump starts up automatically, and as soon as the Ergelit fresh mortar reaches the centrifuge spray head, the winch starts to turn and the spray head projects the corrosion-resistant, waterproofing coating at the shaft wall with a centrifugal force of approx 5000 rpm. As a result, the Ergelit is highly compressed. In laboratory tests, an increase in strength of up to 50% was found. The built-in computer continues to control the coating process, changes the centrifuge motor's direction of rotation, stops and starts the mortar pump, and raises and lowers the centrifuge until the desired thickness is reached. It gives the operator a continuous update on the remaining quantity of Ergelit needed and the distance that remains to be coated. In this way, operators always know how much longer the procedure will take.

The two operators are responsible for keeping up the supply of materials and for monitoring the coating process.

www.hermes-technologie.de

Sturdy screen for coarse material removal

Huber SE is in the position of having a wide range of screens which allows the company to offer every customer the perfect solution for his specific requirements. This guarantees the customers problem-free plant operation. On the basis of the function principle of the multi-rake bar screen Huber has developed the new coarse material screen TrashMax®. The TrashMax® screen offers all the benefits of our multi-rake bar screens and in addition an extra sturdy design for the removal of coarse material. The screen is ideal to be used in pumping stations, as first treatment stage of wastewater treatment plants or industrial plants, and in the inlet to power plants. It removes coarse and bulky material and therefore protects downstream systems.



An important functional element of the screen is its bar rack which retains the coarse material. The screen rakes of the TrashMax® screen mesh with the rack bars at the bottom dead centre, at first with the back cleaned screen and then with the behind front cleaned screen. This avoids the accumulation of material in front of the screen and even extremely bulky objects are reliably removed by the screen rakes and transported upwards out of the channel. As the screen rack gets more and more blinded, flow resistance increases and consequently the water level in the channel in front of the screen rises due to the accumulating material. The Huber TrashMax® screen is able to remove this material very quickly and thus reduce the water level within a short time. The TrasMax® achieves this with its cleaning elements. Attached to the chain system, these elements can easily be adjusted to different requirements and are therefore able to reliably remove even heavy loads and bulky screenings. As the cleaning rakes can be variably adapted, removal capacity is then adjustable. The benefit of high cleaning efficiency is especially favourable for high solids loads.

Both ends of the cleaning rakes are connected to robust drive chains. Two wear-resistant rollers on each side, running in lateral guiding tracks, ensure true and smooth running of the rakes as they move upwards with the result of reliable intensive bar rack cleaning. Each chain is driven by a sprocket on a common shaft and a gear motor. Frequently, screens need to be adaptable to specific site requirements. Especially with given hydraulic and structural conditions the TrashMax® screen is ideal due to its versatility and flexibility. Due to the screen's compact design its height above floor is very low. Also screen installation length is very short as the screen can be installed at angles between 70° and 85°. In short: With this screen type, solutions can be provided for virtually any application, even and especially with given hydraulic and constructional conditions.

As described above, the screen rakes attached to the chain system reliably ensure continuous bar rack cleaning with short removal intervals. The lower part of the TrashMax® consists in the steep conveying section followed by the upper part, the flat discharge section with a small inclination. This screen design guarantees the reliable discharge of screenings into a downstream transport or disposal system. With the development of the new TrashMax® screen Huber has successfully added another innovative coarse material screen to its program of screening solutions.

www.huber.de

30th October 2012
in Brussels

Eighth EWA Brussels Conference

European Year of Water

Upcoming Challenges

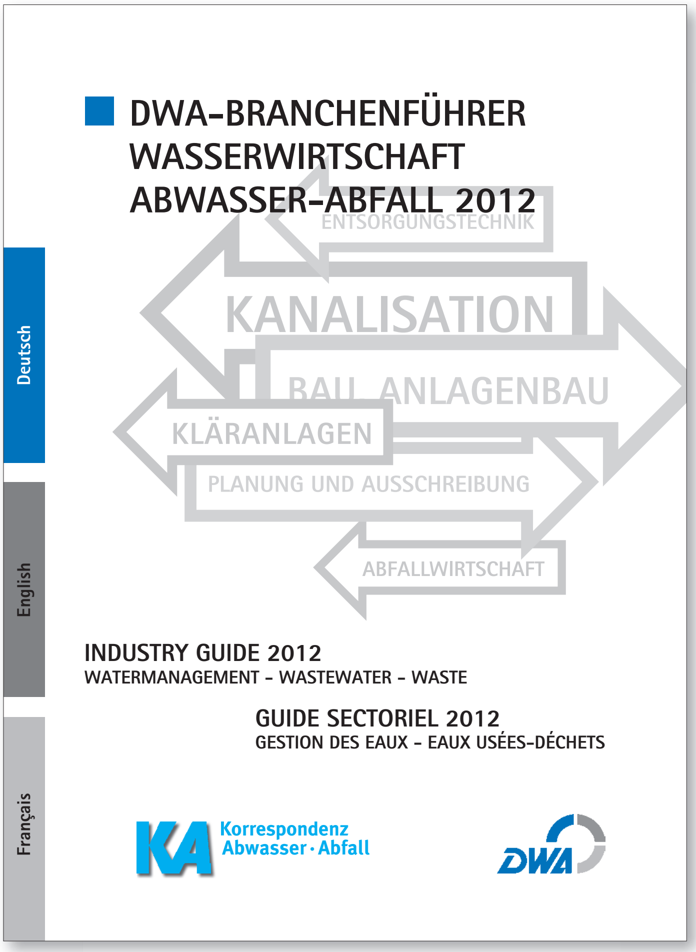
In cooperation with and sponsored by the European Commission

For more information
and to register, please contact:
lorvik@ewa-online.eu
Tel. +49 2242 871-168

Hosted by the Representation of the
State of Baden-Württemberg to the European Union

Industry Guide

Water Management · Wastewater · Waste



The **Industry Guide** of the German Association for Water Management, Wastewater and Waste (DWA) is a capable partner for your search of products and services in the fields of wastewater, waste, hydrology, water engineering, hydropower and much more.

Request a sample copy:
Rita Theus
phone: +49 2242 872-153
e-mail: theus@dwa.de

internet: **www.gfa-news.de**
right side of the screen
"Branchenführer"

See it for yourself!

Fax: +49 2242 872-151

Yes, please send me free of charge
.... copies of the DWA Industry Guide.

GFA
Rita Theus
Theodor-Heuss-Allee 17
53773 Hennef
Germany

Sender

Surname/First name

Firm/Authority

Street

Town/Country/Postcode

Number of DWA Membership (if applicable)

Date/Signature

☐ Yes, I wish to receive further information of DWA/EWA/GFA by e-mail.