Factsheet
Industry

Requirements for water reuse in industry

Challenges

The use of water for different industrial processes (including power generation) requires different service water qualities. Alongside cooling water, flush-, transport-, wash-, product-, and boiler feed water play an important role but in terms of the amount of water required, cooling water is the most important product from this list.

The most crucial quality parameters for the industry are turbidity, suspended solids, dissolved minerals (salts), disinfectants and specific anorganic and organic contaminations. One special focus lies on the microbial contamination relating to biofouling and biofilm formation or through exposure by potential pathogens, such as legionella, coliform bacteria and viruses. The most common water quality problems in cooling water systems are corrosion, biological growth and the formation of boiler scale. In regards to the reuse of treated wastewater special attention has to be brought to these aspects.

Procedure for the regulation of quality requirements

In order to select suitable industrial sectors for the MULTI-ReUse procedure, the industrial water demand of producing industries in Germany was assessed. Sectors with the biggest water demand and use are the chemical industry, followed by the metal industry, food and beverage industry as well as the paper and textile industry. This doesn't change in the international context. The main challenge for wastewater reuse in the industry is the implementation of the different requirements and qualities for service waters. With the help of modular process chains in MULTI-ReUse, different qualities of service water can be provided.

Figure 1: Chemical industry – Pipelines (©industrieblick - stock.adobe.com)

In Germany there is no general legal framework for wastewater reuse in industry but different guidelines, standards and regulations exist for different process waters, especially for cooling and boiler feed water (see table 1). Also, there are different regulations for the general water management that need to be taken into consideration (see table 1). Therein the handling of water-polluting substances as well as the directive for registration and supervision of industrial wastewater treatment plants plays an important part. The specifications of the European Water Framework Directive (WFD) are fully implemented in German law, e. g. the

list of priority substances is implemented in the Ordinance on the Protection of Surface Waters (Oberflächengewässerverordnung – OGewV). From industrial side, the *Directive 2010/75/EU on industrial emissions* needs to be taken into consideration and the related 'Best Available Techniques' have to be implemented.

Based on the directives and guidelines and the challenges mentioned above, three different quality levels of service water were defined: (1) Cooling water, (2) boiler feed water, (3) other process water.

Cooling- and boiler feed water belong to the most important process waters in the industry, which was the reason for defining them as a service water for MULTI-ReUse. Important parameters to consider from the guidelines and DIN-standards in table 1 are: turbidity, pH-value, electrical conductivity, total hardness, acid capacity, solute oxygen, alkaline earths, chloride, sulphate, phosphate, nitrate, ammonium, iron, copper, nickel, chromium, silicate, pesticides, TOC, legionella, pseudomonads and total number of colonies. The quality for the third service water (other process water) is based on the requirements of the German Drinking Water Ordinance to guarantee a broad spectrum of fields of applications. These include the listed chemical, physical as well as microbiological parameters.

International perspective

Since the German requirements are derived from the European requirements, they are similar, and the reuse of water is not regulated uniformly in Europe either. In general, the WFD is used as a guideline for a uniform water policy. Of special importance for the industry are the Industrial Emissions Directive to avoid and reduce environmental pollution and the binding 'Best Available Techniques' conclusions. The European Drinking Water Directive has an important meaning especially for the food processing industry. Next to this general legal framework, a few European countries (see table 2) passed national laws, resp. standards for industrial water reuse.

In Greece for example two different process water qualities are distinguished. The most important parameters here are: *Escherichia coli* as microbiological parameter, BOD5, turbidity and suspended solids. Spain has a similar approach; here there are two process water qualities as well. The first quality is mainly used

Table 1: Most important guidelines, standards and regulations for water management and water reuse of the industry in Germany.

General (Waste) water management

- Wastewater Ordinance (Abwasserverordnung, AbwV)
- Surface Water Ordinance (Oberflächengewässerverordnung, OGewV)
- Groundwater Ordinance (Grundwasserverordnung, GrwV)
- Ordinance about the handling of water-polluting substance for facilities (Verordnung über Anlagen zum Umgang mit wassergefährdenden Stoffen, AwSV)
- Registration and supervision directive for industrial waste water treatment plants (Industriekläranlagen-Zulassungs- und Überwachungsverordnung, IZÜV)
- Water resources act (Wasserhaushaltsgesetz, WHG)

Cooling water

- Guideline series VDI 3803 „Ventilation technology, equipment needs" (Richtlinienreihe VDI 3803 „Raumlufttechnik, Geräteanforderungen")
- Guideline series VDI 2047 „Hygiene for recooling plants" (Richtlinienreihe VDI 2047 „Hygiene bei Rückkühlwerken")
- BREF (12.2001): „Reference Document on the application of Best Available Techniques to Industrial Cooling Systems"

Boiler feed water

- DIN EN 12953-10 Shell boilers: Requirements for feed water and boiler water quality (DIN EN 12953-10 Großwasserraumkessel: Anforderungen an die Speisewasser- und Kesselwasserqualität)
- DIN EN 12952-12 Water tube boilers: Requirements for feed water and boiler water quality (DIN EN 12952-12 Wasserrohrkessel: Anforderungen an die Speisewasser- und Kesselwasserqualität)
- TRD 611 Feed water and boiler water of steam generators (TRD 611 Speisewasser und Kesselwasser von Dampferzeugern)
- VdTÜV MB TECH 1453 VdTÜV Directive for feed water, boiler water and steam of steam generators up to a allowed working overpressure up to 68 bar (VdTÜV MB TECH 1453 VdTÜV-Richtlinien für Speisewasser, Kesselwasser und Dampf von Dampferzeugern bis 68 bar zulässigem Betriebsüberdruck)
- VGB R 450 L Feed water, boiler water and steam quality for power plants/industrial power plants (VGB R 450 L Speisewasser-, Kesselwasser- und Dampfqualität für Kraftwerke/Industriekraftwerke)
- Directives, resp. guidelines of the respective boiler manufacturer (Richtlinien bzw. Betriebsvorschriften des jeweiligen Kesselherstellers)

Other process water

- Drinking Water Ordinance (Trinkwasserverordnung, TrinkwV)

for process- and flush water purposes, the other one for cooling waters and evaporative condensers. Next to *E.coli,* nematodes, salmonella and legionella are mentioned as microbiological parameters.

The most important global and country-specific guidelines are those of the WHO, the United States Environmental Protection Agency (US-EPA), the guidelines of California and Australia as well as the ISO guideline yet to be drafted. In addition, guidelines from Japan, South Africa, China and Singapore provide details on industrial water reuse, but the most detailed when it comes to industrial water reuse are the US-EPA Guidelines for Water Reuse. Here you will find clear quality criteria for cooling and boiler feed water as well as a general overview of process water in industry and the corresponding quality criteria of the individual countries.

Conclusion

The reuse of municipal wastewater in an industrial environment can contribute to a more independent industry and serve as a relief to water resources especially in arid or other regions that suffer from water stress. In Germany target markets for the developed technologies could be industrial conurbations, coastal sites, urban agglomerations or regions with intense agricultural productivity.

An important question still to answer is the distribution of the three service waters to the consumers. These should be close locally. A supporting government and possible subsidisation could speed up the implementation on the market. That way costs could be reduced, e. g. there would be lower disposal costs for wastewater, savings of drinking water or reduction of energy costs. Further advantages could be a flexibilisation of the companies that have allocated water contingents, resulting in them having to reduce production in peak times or preventing them from expanding.

Defined legal frameworks and competitive prices for reused water would promote the implementation of water reuse remarkably. The suggestions for the three different service waters in the MULTI-ReUse project are an important contribution to this.

Table 2: Most important European and international guidelines for water management and water reuse of the industry.

General (Waste) water management

- Water Framework Directive – WFD (2000/60/EC)
- Drinking Water Directive – 80/778/EC revised with 98/83/EC
- Bathing Water Directive – 2006/7/EC
- Groundwater Directive – 2006/118/EC
- Directive 2013/39/EU of the European parliament from 12. August 2013 about the change of the directives 2000/60/EG and 2008/105/EG in regards to priority substances in water policies (UQN-RL)
- Urban Wastewater Treatment Directive – UWWTD 91/271/EEC amended by 98/15/EEC
- Directive 2010/75/EU on industrial emissions, BVT resp. BAT and BREFs

European national directives for water reuse in industry

- Greece (Κοινή υπουργική απόφαση 145116/11)
- Italy (Decreto del Ministero dell'ambiente 185/2003)
- Portugal (Padrão Português NP4434, 2006)
- Spain (Real Decreto 1620/2007)

International directives for water reuse in industry

- ISO/TC 282, Water reuse (under development)
- ISO 16345:2014 Water-cooling towers – Testing and rating of thermal performance
- ISO 16784:2006 Corrosion of metals and alloys – Corrosion and fouling in industrial cooling water systems
- ISO 5667:1993 Water quality – Sampling
- US EPA, 2012: Guidelines for water reuse California regulation related to Recycled Water, Title 22 of the Code of regulations, Title 22, Division 4, Chapter 3
- NWQMS 2006, Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)
- Japan, Tokyo: Reclaimed Water Quality Criteria
- South African Water Quality Guidelines, Volume 3, Industrial Use, Second Edition, 1996
- China National Standards: The reuse of urban recycling water-Water quality standard for industrial uses (GB/T 19923-2005)
- Singapur: NEWater Quality

Short description of the MULTI-ReUse project

Treated wastewater is an important part of the water cycle. It usually is fed into rivers, something that is acceptable from an environmental point of view but for the use in agriculture or industry the water often is unsuitable. MULTI-ReUse closes this gap by developing and implementing of new procedures for the reuse of service water. The aim of MULTI-ReUse therefore is the development, demonstration and evaluation of a modular water treatment system, in order to offer service water in different qualities and quantities for the different purposes and to competitive prices.

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