Industriewassertag

AK Industriewasserwirtschaft & GEMÜ

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German Water Partnership

GEMÜ

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Industrial Water Compendium

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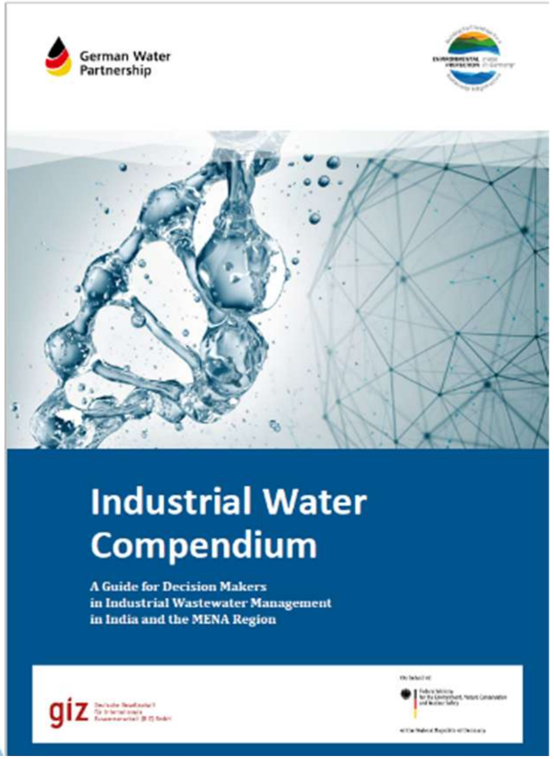

Industrial Water Compendium

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via solvent recovery systems. In general, the pharmaceutical industry is facing a challenge due to the great variation in the quantity and characteristics of the individual production wastewaters involved, as well as the extreme persistence and poor biodegradability of many contaminants [illegible].

Treatment processes

Biological cleaning

Wastewater treatment in the pharmaceutical industry is traditionally carried out by means of biological cleaning processes. The wastewater often contains a readily biodegradable organic load. However, there are often substances in the wastewater that have poor biodegradability or can even have a toxic effect on the biological agents. This is a challenge for numerous biological cleaning processes. The biodegradability of a chemical compound depends mainly on its stereochemistry, toxicity and concentration levels. From an operational point of view, the suitability of the particular microbial strain involved, the degradation conditions and the time spent in the biological stage play an important role [illegible].

Aerobic processes are most commonly used in the pharmaceutical industry for wastewater treatment, as they are very robust in operation. Activated sludge processes including sedimentation and long sludge retention times are often the means of choice, although membrane bioreactors are also increasingly utilised to achieve a high effluent quality. Aerobic processes have proven successful for the degradation of many active pharmaceutical ingredients (e.g. ibuprofen, naproxen, bezafibrate and oestrogens), but they have their limits, especially with sulphonamides (e.g. sulphamethoxazole, clopamide and sotalol). Anaerobic processes are less commonly used because, on a comparative basis, they are susceptible to a number of pharmaceutically active substances and disinfectants [illegible].

In recent decades, increasing attention has also been paid to active pharmaceutical ingredients in wastewater. Although these substances occur in comparatively low concentrations, they are difficult to remove and have a high level of environmental toxicity. The removal of these active substances as close as possible to their source (i.e., on a decentralised basis within the wastewater stream involved) serves the following goals, among others:

- Removal of substances with a toxic effect on biology
- Increasing the biodegradability of the water
- Removal of non-biodegradable contaminants

Depending on the general conditions and the wastewater matrix, it may also make sense to further purify the wastewater stream following biological cleaning. In both cases, the removal of persistent active pharmaceutical ingredients is achieved by advanced physico-chemical cleaning processes. The most commonly used processes are [illegible]:

- Coagulation and flocculation
- Precipitation
- Adsorption
- Oxidation
- Membrane filtration

Even though, in many locations, there are still no binding limits in place for the discharge of certain active pharmaceutical ingredients, advanced purification is already widespread in many pharmaceutical production plants. One reason for this is that companies operating globally often set high operational quality standards that have to be met regardless of local regulations.

The reuse of treated wastewater in the pharmaceutical industry is only considered, if at all, for non-production applications. This is because of the very stringent quality standards imposed at an international level on the use of pure water streams for production and cleaning purposes. Discharge into the environment is also problematic due to contaminants. In contrast, there is more potential in the recovery and reuse of other raw materials, such as solvents, acids and individual active ingredients. These recovery approaches often rely on the operation of an efficient and decentralised secondary wastewater treatment system [illegible].

Oxidation

A number of chemical compounds that have poor biodegradability and are difficult to remove from wastewater by adsorption can be successfully eliminated by oxidation processes. Oxidation products are formed from the original molecules as a result of reaction with oxygen. It is often observed that these oxidation products are more easily degradable in a subsequent biological stage than the original substances. However, it should also be noted that the resulting reaction products are not fundamentally harmless and, in some cases, may even be more toxic than the original substances.

The most frequently used oxidation process in industrial wastewater treatment is treatment with gaseous ozone. The ozone molecules react selectively with certain functional groups of the wastewater matrix but they also decompose to form hydroxyl radicals, which oxidise wastewater components less selectively and have a higher oxidation potential. Ozone processes are widely used in the pharmaceutical industry, for example for the targeted removal of antibiotics from wastewater streams [illegible].

As an alternative to ozonation, advanced oxidation processes are increasingly being used. These are mainly aimed at the formation of non-selectively reacting hydroxyl radicals and are intended to reduce the formation of problematic oxidation products. There is a wide range of tried-and-tested processes available, from homogeneous to heterogeneously catalysed reactions. The catalysts used are usually transition metals, while an external energy source, such as UV radiation, can also be deployed. Common advanced oxidation processes for wastewater treatment include [illegible]:

- Combination of ozone and hydrogen peroxide
- (Photo) Fenton process with iron salt as catalyst
- Electro-oxidation
- TiO_2 photocatalysis (currently at pilot scale)

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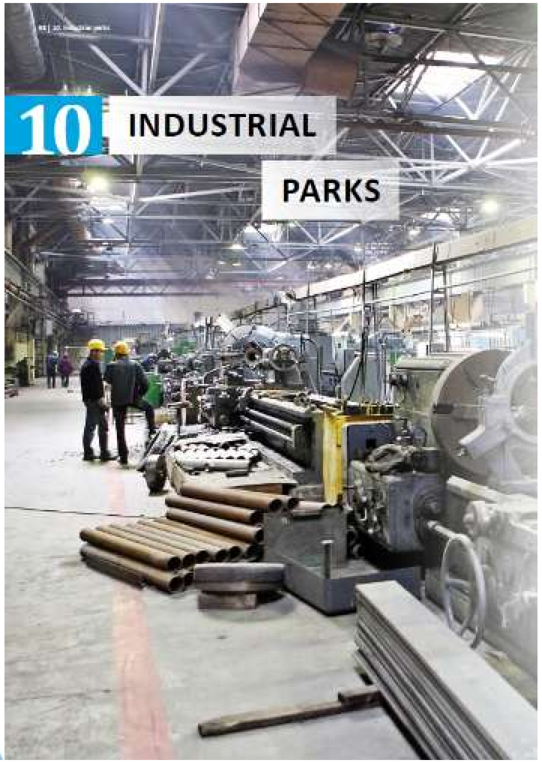

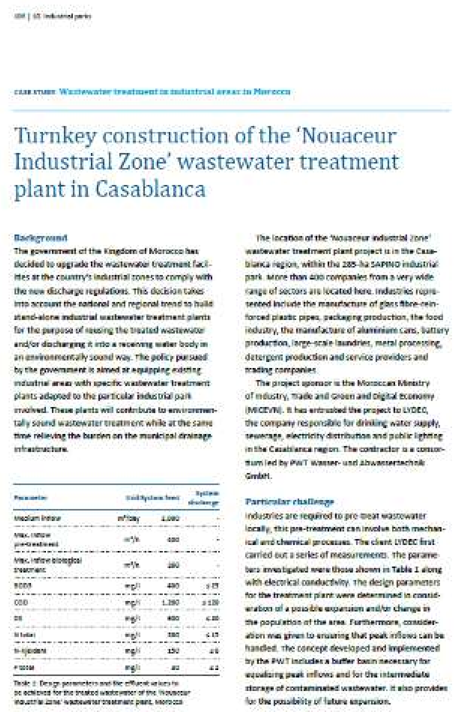

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