Effectively removing medicine residues from wastewater

More and more medicines are being developed for a growing number of applications. As a result, treating wastewater from the pharmaceutical industry is an increasingly demanding task. Alongside thorough analytical methods, EnviroChemie offers a range of processes for reliably removing critical substances from industrial wastewater.

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Residues of medicine can be detected in water. This is the case for antibiotics, hormones and many other types of medication that people take or apply to their skin as an ointment. Wastewater is contaminated with residues of active pharmaceutical ingredients even during the production of pharmaceutical ingredients.

These substances can potentially harm people and animals, especially when a number of them accumulate in the environment over time. In particular, the range of medicines is steadily increasing, while at the same time more and more pharmaceuticals are being consumed due to demographic change. Therefore, the problem will inevitably be exacerbated in the future.

Active pharmaceuticals are not easily biodegradable

Only the active pharmaceutical ingredients (API) have a medicinal effect. “A considerable portion of the medication is excreted and ends up in wastewater in unchanged form or as a degradation product,” comments Elmar Billenkamp, graduate engineer and department head at EnviroChemie.

As a result, high concentrations of APIs contaminate wastewater in pharmaceutical plants and traces of the residues can ultimately also be found in municipal sewage treatment plants. They are generally not easily biodegradable. Therefore, the wastewater may not be discharged into sewage treatment plants without pretreatment. If wastewater experts deem certain APIs to be ecotoxicologically harmful, they should preferably be eliminated immediately at their source.

The pharmaceutical industry is therefore faced with the challenge of removing these residues from water effectively and cost-efficiently without harming the environment in the process. “The tasks to be performed when treating wastewater from pharmaceutical production are becoming ever more diverse,” says Billenkamp, who adds that complex wastewaters are also subject to significant fluctuations: “We are also seeing ever more new active ingredients and applications.”

One striking example is the surfactant octoxynol 9, which is used as a solution in many rapid tests for COVID-19 and is therefore a prime example of a substance that can suddenly present a completely new challenge for wastewater. Octoxynol is sold under the trade name Triton X-100 and may not be released into wastewater, even in small quantities, due to its toxicity. As a result of the increased quantities of this material that are now being produced and sold, producers are now tasked with developing completely new solutions – and the expertise of wastewater experts is indispensable here.

Eliminating problematic ingredients at source

While the requirements are becoming ever more stringent, analytical techniques are also continuously improving, as Billenkamp emphasises: “We have the wastewater examined

ecotoxicologically in special laboratories. For this, our Research & Development department works together with universities and institutes."

The extent to which the wastewater needs to be cleaned is determined by what is known as the PNEC value of a substance, which is defined in environmental laboratories. This stands for "predicted no effect concentration" and refers to the threshold value of a toxic substance in water at which it has been proven to have no effect on the environment. Substances in water below the PNEC value are therefore deemed acceptable, and the wastewater can be discharged.

Reducing the carbon footprint

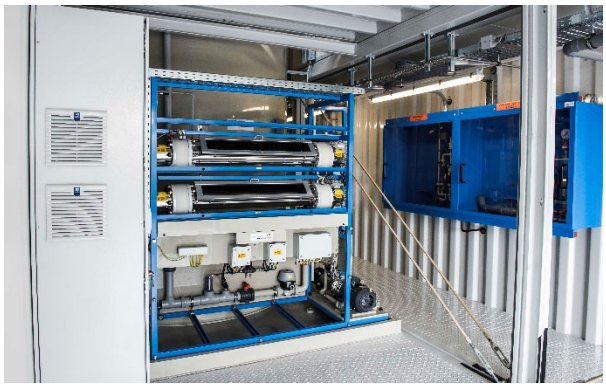
Different methods can be considered for pretreating wastewater from pharmaceutical production. Multiple technologies can even be combined here.

Companies often have aqueous waste incinerated by external providers. This is highly cost-intensive, however, as the water must first evaporate before the solids can burn. Alongside the high energy consumption, a considerable amount of CO_2 is emitted. "And the lorry transport also increases the carbon footprint," explains Billenkamp.

Physical procedures are also expensive. Residues in wastewater are filtered out using membrane technology or absorbed by activated carbon. Following this, the company has to pay to have these residual materials disposed of. Depending on the type of wastewater, however, these methods can be suitable in combination with other technologies.

Advanced oxidation process for pretreating wastewater

"The ingenious advanced oxidation processes are more common today," explains Billenkamp. APIs or other substances that are not easily biodegradable are split into smaller organic fragments during these processes, known for short as AOPs. After all, many of the substances consist of long-chain molecules that cannot be broken up by bacteria in the sewage treatment plants.



Removal of active pharmaceutical ingredients (API) using UV and hydrogen peroxide

During oxidation, for example, ozone or hydrogen peroxide (H_2O_2) combined with UV light result in the creation of hydroxyl radicals (OH radicals), which react with nearly all oxidisable substances especially quickly and strongly. As such, the complex molecules of the harmful substance are broken down into smaller organic fragments, which are no longer critical and can subsequently be treated biologically.

The type and composition of the wastewater is decisive

Which AOP process is the most effective depends on the type of wastewater and its components. "Most companies specialise in one procedure. However, we are not limited to a single procedure," says Billenkamp. The wastewater experts from EnviroChemie test the various processes for the different pharmaceuticals in the company's own labs and pilot plants in order to find a solution.

“Together with our customers, we develop the right water treatment method for each individual case.”

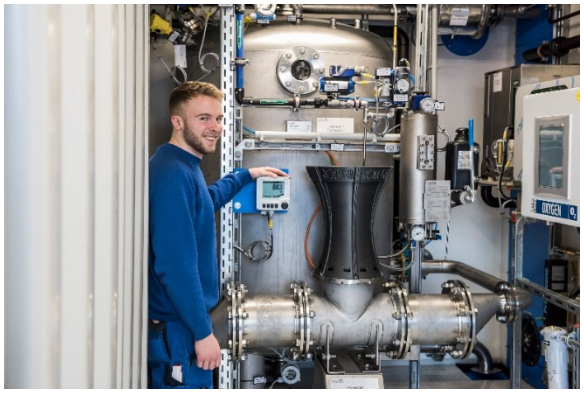
For example, EnviroChemie has worked together with Roche and IUTA (Institute for Energy and Environmental Technology) in Duisburg to develop a procedure for removing traces of pharmaceutical substances from the wastewater of a new production plant in Mexico. One of these substances was the active ingredient capecitabine (API) from a cancer medication, which had been classified as ecotoxicologically critical following analyses. Here, the ozone oxidation AOP scored ahead of UV/H_2O_2 and activated carbon in terms of its ecological and economic aspects in particular. It was first tested in the laboratory before being implemented on an industrial scale.

Analysing wastewater again and again

“We have to analyse the composition of the wastewater again for every project and adapt our treatment accordingly,” describes Billenkamp: how much hydrogen, how much peroxide is needed to eliminate the harmful substances to the extent that the wastewater is no longer problematic? Do fillers have to be filtered out first? How long does the wastewater have to be treated for – 20 minutes, an hour or longer? Or what capacity do the UV lamps need in order to function ideally?

In order to individually devise a plant solution, the full expertise of the specialists needs to be called upon during every project. In this way, EnviroChemie employees collect experience on the optimum use of resources for many different wastewater types, while at the same time the Research & Development team enhances new technologies and existing processes.

Alongside the method adapted to the wastewater, the right dosage and the duration of treatment, the treatment of wastewater can also be optimised by fine-tuning process engineering aspects. EnviroChemie belongs to the EnviroWater Group, a specialist network of companies, which means it is well positioned when it comes to wastewater treatment. For example, up2e! has developed the Roturi® process for applications with ozone, which allows ozone to be used particularly efficiently for removing active pharmaceutical ingredients.



AOP using ozone with a Roturi device for the safe removal of medicine residues from wastewater

EnviroChemie works together with companies from the pharmaceutical industry to develop sustainable alternatives to the thermal combustion of API-contaminated wastewater. “The processes are designed in such a way that they can be flexibly adapted when the composition of the wastewater changes,” comments Billenkamp, “and they should pay for themselves over the long term.”

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