More targeted treatment of industrial wastewater thanks to aquatic research

March 5, 2024 | Andri Bryner
Topics: Wastewater | Pollutants

In Switzerland, wastewater treatment has traditionally focused on domestic wastewater – in particular, the removal of organic matter and phosphorus. Only more recently has attention also been focused on problematic residues of medicines, pesticides and other chemicals. A new Eawag study now shows that there is also potential for improvement in the case of emissions from chemical and pharmaceutical plants – both at wastewater treatment plants and within the industrial facilities.

Almost 40% of Switzerland's wastewater treatment plants (WWTPs) have chemical or pharmaceutical plants within their catchment and thus potentially also treat emissions from these facilities. Frequently, however, it has not previously been known precisely which substances, or what concentrations, these emissions contain, and by no means all substance residues are currently eliminated by WWTPs. Two new Eawag studies, just published in the journal Aqua & Gas, show how site-specific measurement campaigns can help companies to improve their production processes or wastewater pretreatment. The aim is to reduce releases of unwanted substances into wastewater, WWTPs and ultimately the environment.

From measurement campaign to targeted measures

For wastewater discharged from chemical or pharmaceutical plants into receiving waters or public sewers, the maximum permissible concentrations for sum parameters (e.g. total hydrocarbons) or for single substances such as heavy metals or solvents are specified in the Swiss Water Protection Ordinance. But for most organic compounds no limits are specified in the Ordinance; instead, the requirements for individual substances have to be specified by the authorities [A1] based on the state of

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the art. The management of such micropollutants thus poses major challenges for the authorities and companies alike. Often, these substances are not routinely measured in industrial wastewater – even though the various compounds may be relevant for water protection on account of their persistence, mobility, or effects on aquatic organisms. However, measurement data can provide important information enabling existing on-site measures to be improved in a targeted manner. Accordingly, in the two studies published today[A2] , Eawag – together with industry – used state-of the-art measurement techniques to investigate the complex composition of industrial wastewater.

Considerable differences between manufacturing and processing

Both studies were carried out in collaboration with cantonal agencies and the chemical/pharmaceutical industry. The first study was concerned with wastewater from substance manufacturers (synthesis plants). Most of these plants have their own wastewater treatment facility or are connected to an industrial WWTP along with other companies. In their wastewater, as expected, a wide variety of substances were found, comprising starting substances, intermediates and finished products. The number of different substances measured at industrial WWTPs was up to 15 times higher than at those receiving exclusively municipal wastewater.

The second study involved plants which process active ingredients into products such as tablets, capsules, solutions, creams, etc. (formulation plants). Here, the variety of substances found was considerably lower. However, short-term peak concentrations were detected in wastewater arising from the cleaning processes which take place when new batch production begins.

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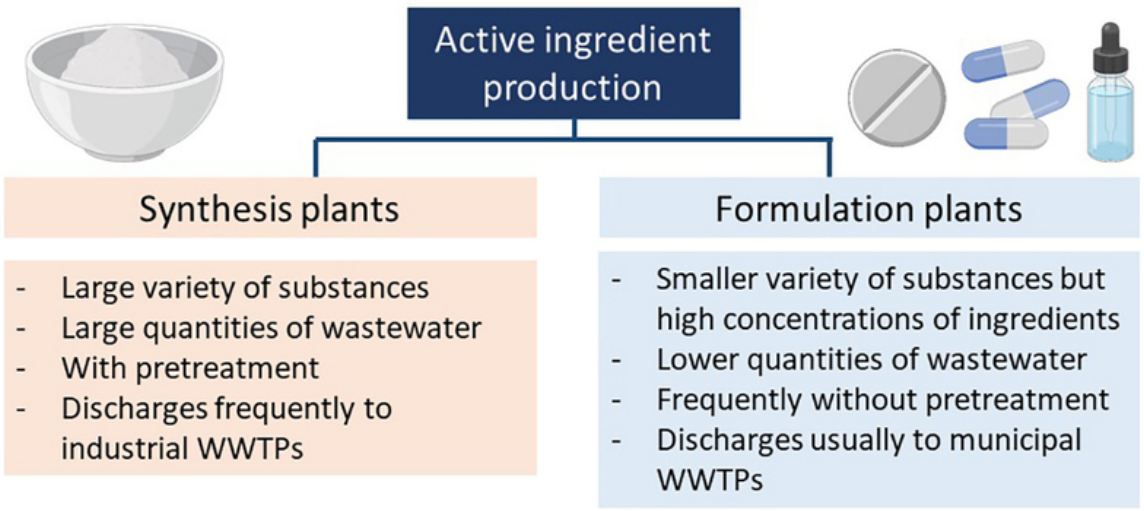

Typical differences between pharmaceutical synthesis and formulation plants. (BioRender graphic)

Signals from bioassays

Whether a substance poses risks to the aquatic environment depends not only on its concentration but also on its toxicity or persistence. Accordingly, one of the participating synthesis plants – in collaboration with a private laboratory – also conducted ecotoxicity tests with algae and macrophytes (aquatic plants); the aim was to identify the most relevant substances and prioritize possible measures. The bioassays showed that wastewater toxicity was sometimes attributable to a single component, and that low concentrations may also be relevant for ecotoxicity. Based on these findings, the plant concerned was able to modify its production processes, substantially reducing wastewater toxicity.

Also notable was the fact that companies' production cycles could be demonstrated even a long way downstream on the basis of peak concentrations. For example, after four days, the Rhine monitoring station below Basel observed peaks clearly attributable to an industrial plant's methadone production more than 100 km upstream. Thus, as the study authors note, "Wastewater from a single plant can influence surface water quality far downstream even when it is highly diluted." Thanks to the information provided by the measurements in the Rhine, the plant was able to respond rapidly to the unwanted losses.

Short-term peaks after cleaning operations

For the study involving formulation plants, the researchers also utilized the mobile, automated mass spectrometer MS2field (see the video link below), which allows high temporal resolution measurements to be made in wastewater almost in real time. They thus also detected active substances not normally found in municipal wastewater, such as those from medicines produced exclusively for the export market. As a result of pulsed inputs, e.g. after the cleaning of systems and containers, active substance concentrations of up to 1 mg/L were measured in WWTP influents. These short-term peak concentrations are several orders of magnitude higher than those normally occurring with domestic wastewater inputs.

Benefits of pretreatment

At conventional WWTPs, substances from chemical/pharmaceutical plants are sometimes poorly eliminated. However, as both studies show, production plants with effective pretreatment facilities can significantly reduce their substance emissions. In formulation plants, simple on-site measures can often make a big difference. For example, measurements at two plants revealed that highly concentrated solutions were inadvertently being discharged directly to the WWTP. Thanks to this information, the plants were able to stop these inputs with minimal effort. In the case of synthesis plants, because of the more complex processes, emission reduction measures are required at various stages, from the production site to the central WWTP.

The studies and the collaboration between researchers and industry have thus raised awareness of chemical/pharmaceutical wastewater issues among all parties and have already led to a number of improvements. The findings should therefore support the efforts of other plants to reduce inputs of contaminants to surface waters.

Original publications

Abwasser aus chemisch-pharmazeutischen Synthesebetrieben. Julian Bosshard; Kathrin Fenner; Heinz Singer, Eawag: Sabine Anliker, ehemals Eawag; Rebekka Gulde, Plattform «Verfahrenstechnik Mikroverunreinigungen»,Aqua und Gas 3/2024.

Abwasser aus der Formulierung von Arzneimitteln. Julian Bosshard, Eawag; Fabienne Eugster; Rebekka Gulde, VSA-Plattform «Verfahrenstechnik Mikroverunreinigungen»; Heinz Singer, Eawag; Aqua und Gas 3/2024.

Cover picture: The mobile mass spectrometer MS2field – deployed here at a wastewater treatment plant – permits automated measurement of contaminants at extremely low concentrations with high temporal resolution. (Photo: Eawag)

Financing / Collaborations

The two studies on which this text is based (original publications in Aqua & Gas 3/2024) were co-financed by the FOEN. The authors would also like to thank the participating companies, the cantonal authorities, and staff at the WWTPs involved.

Video MS2field

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