Switzerland: Where improved wastewater treatment protects aquatic organisms

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Sanitation Wastewater Pollution

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English

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- Switzerland introduces advanced wastewater treatment to reduce the release of micropollutants.
- Ozonation combined with an additional post-treatment step improves the quality of treated wastewater.
- By measuring biological responses using a variety of bioassays, improvement in the quality of wastewater can be assessed.

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It is the year 2023, but conventionally treated wastewater is still a chemical burden on the aquatic environment.

There are many chemicals present in wastewater that we do not know enough about. We do not know how they change during the treatment processes. We do not know how to monitor them efficiently.

Micropollutants, such as those found in pharmaceuticals and personal care products can have far-reaching effects on aquatic organisms that are still not fully understood. These chemicals can impact streams and lake ecosystems, and ultimately reach the ocean where their role in the disruption of marine food chains is only just being unravelled.

Conventional wastewater treatment with nitrification does not effectively remove micropollutants. Therefore, an additional advanced treatment step is required. The most efficient advanced treatment methods are 1) the addition of activated carbon, which binds micropollutants, and 2) ozonation, which breaks down micropollutants.

In 2016, Switzerland revised its water protection law to protect aquatic ecosystems and drinking water resources and to minimise pollutant discharge. The country has made a 20-year commitment to upgrade approximately 130 of its existing ~800 wastewater treatment plants (WWTPs). This effort will result in the advanced treatment of more than 50% of Switzerland's entire effluents discharged into freshwater bodies. The goal is an 80% reduction of micropollutant concentrations in effluents released by these upgraded plants.

Ozonation is one of the most economic and effective advanced wastewater treatment methods available. Ozone is a strong oxidant and produces fewer potentially problematic by-products from organic matter than chlorine, which is widely used to disinfect water. However, only a few countries, among them Germany, Sweden and Switzerland, currently implement full-scale ozonation as part of their wastewater treatment processes.

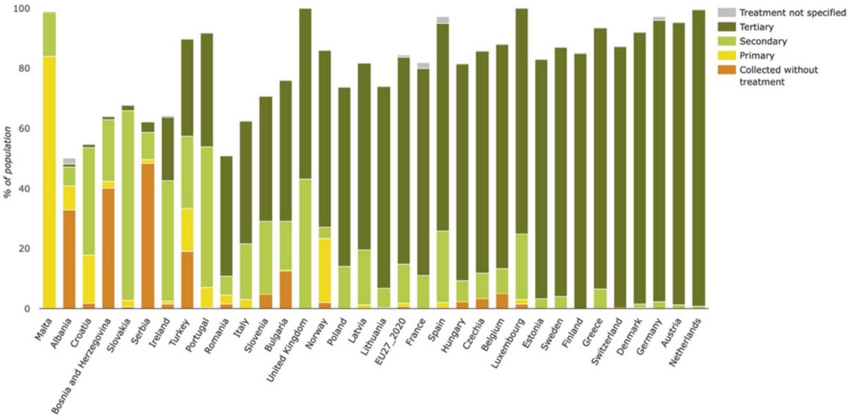

Figure 1. Proportion of urban wastewater collected and the level of treatment implemented as a percentage of the population across European nations. Source: European Environment Agency

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This article is based on the authors' original publication Evaluation of a full-scale wastewater treatment plant with ozonation and different post-treatments using a broad range of in vitro and in vivo bioassays published in Water Research, a journal of the International Water Association.

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However, ozonation has some known drawbacks. The process can generate products that are reactive and potentially toxic to aquatic organisms. Reaction products can either be more or less toxic than their parent compounds, and little is known about the effects of these compounds as complex mixtures.

Because of such uncertainties, Swiss regulations recommend additional biological post-treatment of ozonated effluents such as the use of sand filters, but other treatments may be similarly effective.

The focus of our study was to assess the water quality of conventionally treated wastewater after ozonation alone and in combination with different post-treatments at the WWTP Neugut in Dübendorf, Switzerland. Neugut is the first WWTP in the country to use advanced wastewater treatment processes at full-scale (Figure 2). Its capacity is equivalent to wastewater produced by 150,000 people; although, 50% of its inflows are from food and fragrance industries.

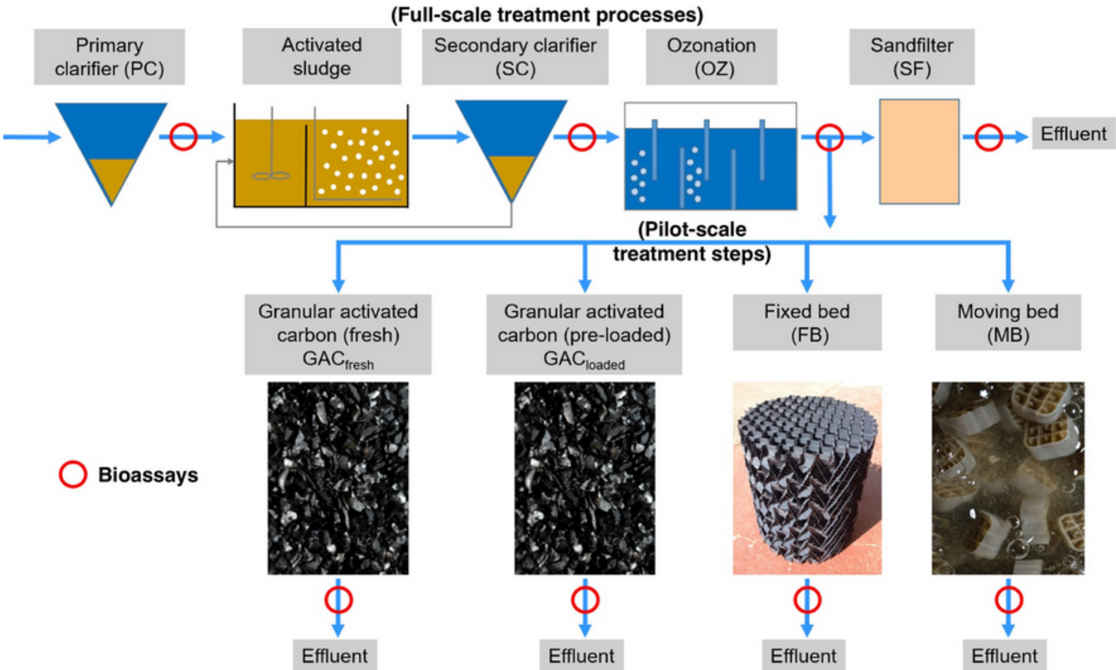

Figure 2. Treatment steps at the Neugut WWTP.

The goals of the study were (1) to monitor the efficacy of ozonation in removing toxicity from wastewater and the biological effects of products formed during ozonation, and (2) to compare the efficacy of several different post-treatment methods in reducing any remaining toxicity in the ozonated wastewater.

Fourteen different bioassays were applied at several stages of the treatment process (Figure 2). The aim was to observe how treated wastewater affects a variety of biological functions of different organisms, e.g. if and how genetic material was transformed or damaged, if tissue cells underwent oxidative stress, or if endocrine activities were disrupted.

To achieve this, water samples were tested in the laboratory using cell cultures, bacteria, algae and water fleas. The reproduction of oligochaete worms and the development and survival of early live stages of rainbow trout were measured in flow-through systems installed directly at the WWTP. Development parameters in rainbow trout included hatching and swim-up success, growth, tissue lesions and the expression of pollutant-sensitive genes as biomarkers.

Results showed that ozonation reduced various ecotoxicological effects by 66 - 93%. It was particularly effective in improving photosynthetic activity of green algae, reducing hormonally-active compounds, and reducing toxicity to luminescent bacteria. Mutagenicity (the potential to permanently transform DNA) was observed only occasionally after ozonation, but this effect was eliminated by most post-treatment techniques, with the best results observed with the granular activated carbon filter. Overall, the formation of reaction products during ozonation was below levels that would cause any concern if a post-treatment step was included.

Our study shows the considerable efficacy of ozonation and biological post-treatments for the advanced treatment of wastewater, with best results achieved by a combination of ozonation and granular activated carbon filters.

The study's relevance goes beyond the Swiss context by showing the usefulness of applying a range of bioassays to assess water quality. This holistic approach to toxicity testing is particularly relevant when applied to matrices with partially or completely unknown chemical composition.

The significance of wastewater treatment was recognised in the proposal for a new urban wastewater treatment directive in the EU. The directive will play a key role in the European Green Deal's zero pollution ambition. As the global water stress deepens, wastewater is increasingly being seen as an opportunity. Advanced wastewater treatment technologies can protect aquatic ecosystems and our drinking water resources, or even produce potable water.