Information sheet
FAQs on micropollutants in natural waters

Micropollutants and their transformation products are being increasingly detected in Swiss waters. This is attributable partly to ever more powerful analytical methods, but also to a steady rise in the use of man-made substances. Public awareness of this issue has been heightened in particular by the findings of research on endocrine disruptors – e.g. the feminization of male fish due to estrogens in water. As Europe's "water tower", Switzerland has a special responsibility towards its neighbours. It is therefore rightly one of the leading countries involved in studies of aquatic micropollutants.

What are micropollutants and where do they come from?

Micropollutants are trace organic contaminants or metals found in waters at very low concentrations (billionths to millionths of a gram per litre). By way of comparison, a billionth of a gram (nanogram) per litre is roughly the concentration of the active ingredient of a headache tablet in a 25-metre swimming pool, or of 1 kg of active substance in Lake Biel. The compounds in question are pesticides, pharmaceuticals, biocides, ingredients of personal care products, waterproofing agents, detergents, paints, etc., which find their way into natural waters from a wide variety of sources – agriculture, households, construction and transport. Given the proliferation of chemical applications and the ageing of the population, the consumption of such compounds will continue to rise in the future. The fact that even low concentrations can add up is shown by the example of the antiepileptic drug carbamazepine: concentrations of around 15 ng/L are measured in the Rhine near Basel, which means that more than 1 kg of this highly potent substance is carried downstream each day.

How are micropollutants measured?

The detection of micropollutants was only made possible by the development of increasingly powerful methods of chemical analysis (e.g. liquid chromatography coupled to mass spectrometry, LC/MS) – advances in which Eawag has played a key role. As well as chemical analysis, surface water or wastewater samples are frequently subjected to ecotoxicological testing: this typically involves the use of fish, microcrustaceans or algae. In addition, tests may be carried out to screen certain groups of substances for specific effects, such as estrogenic activity, neurotoxicity or inhibition of photosynthesis. Bioassays allow scientists to assess the effects of complex mixtures of pollutants on the health of aquatic ecosystems. The Ecotox Centre and Eawag are seeking to reduce the number of fish tests by developing alternative methods involving cell lines or computer models. Methods are also being continuously refined because most standard tests are designed to assess the acute toxicity of substances (high concentrations and short exposure times). They are not suitable for evaluating long-term or subthreshold impacts of micropollutants.

How and when do micropollutants exert their effects?

Whether a substance enters a waterbody will depend on its physicochemical properties. Substances which are readily soluble in water and persistent pass virtually unimpeded through wastewater treatment plants (WWTPs) and can generally be detected in receiving waters. Particularly long-lived compounds such as radiocontrast agents are also found in groundwater. High concentrations occur especially in small rivers or streams which receive discharges of effluents from large or from several WWTPs. In most cases, these substances exert in an undesirable manner precisely the same effects as were desired when they were originally applied – but now affecting different organisms: pesticides used to control weeds inhibit photosynthesis in algae, neurotoxic insecticides damage the nervous system of aquatic organisms, and endocrine disruptors from contraceptives or plastics impair the reproduction of fish. However, more subtle forms of damage may also occur – e.g. to organisms' behaviour or immune system. The situation is further complicated by the fact that similar compounds and transformation products may produce additive or unexpected effects. In addition toxicity may also be affected by other stressors such as ultraviolet radiation or increased temperatures.

Facts and figures

- In Switzerland, over 30,000 substances are in daily industrial, commercial or domestic use.
- In agriculture, around 1300 tonnes of pesticides are applied per year.
- In urban areas, an estimated 2000 tonnes of biocides are used per year.
- In private households in Switzerland, more than 500 tonnes of medicines are consumed per year, with around 170 tonnes entering wastewater via excretion.
- The approval of active pesticide ingredients is regulated by the Biocidal Products Ordinance and the Pesticides Ordinance; pharmaceuticals are approved by the Swiss Agency for Therapeutic Products (Swissmedic).
- The Water Protection Ordinance currently only specifies an individual-substance limit of 100 ng/L for organic pesticides (biocides and crop protection products), plus effect-based limits for heavy metals. As yet, no effect-based limits are specified for other substances. Likewise, endocrine disruptors are not covered by existing legislation.

Based on distribution, type of application, properties and effects, Eawag – in cooperation with the Federal Office for the Environment (FOEN), cantonal water protection agencies and industry – has selected a range of micropollutants of relevance in Switzerland, which in future can be included in cantonal monitoring programmes. On this basis, in collaboration with the Ecotox Centre, an approach has been developed for assessing the risks associated with micropollutants. At present, they do not

pose a hazard to public drinking water resources; however, measures should still be taken in the interests of precautionary consumer protection.

How can micropollutants be removed from wastewater?

The mechanical/biological WWTPs which are widely used today are primarily designed to remove solids, dissolved organic compounds and the nutrients phosphorus and nitrogen from wastewater. Nonetheless, a wide variety of micropollutants are already eliminated as a result of being biodegraded or accumulating in sewage sludge. However, certain substances – including endocrine disruptors – are still found in treated effluent at concentrations which have effects on receiving waters and aquatic organisms. For this reason, Eawag has carried out laboratory and large-scale tests involving methods capable of removing unwanted micropollutants from wastewater. In some cases, these experiments drew on existing knowledge from drinking water treatment. But certain methods had to be rejected – for example, because they were not sufficiently efficient (ultraviolet irradiation), required excessive energy, or produced large quantities of waste products (nanofiltration). One approach which proved suitable is the treatment of biologically treated wastewater with ozone or powdered activated carbon (PAC). Ozone has a strong oxidizing action – i.e. many chemical compounds are attacked by this agent and transformed into substances which are biodegradable and/or no longer show ecotoxic effects after subsequent sand filtration. In the case of PAC treatment, the substances are bound to the surface of the carbon and disposed of with the dried sewage sludge (incinerated).

Is the technology sufficiently mature for WWTPs to be upgraded?

Large-scale and relatively long-term experiments carried out by Eawag (partly sponsored by the FOEN) at the Regensdorf and Opfikon WWTPs demonstrated that both ozonation and the addition of PAC can be integrated relatively straightforwardly into existing plants. The results of pilot studies at the Vidy WWTP in Lausanne are also highly promising. With appropriate instruction, both processes can be operated by existing WWTP personnel. Depending on the local conditions (available space, wastewater composition, etc.), one or other of the processes will be more suitable. At present, no other methods appear to be in prospect which would effectively eliminate a similar range of substances with a reasonable level of costs and energy consumption. On points of detail, such as choice of material and control systems, process engineering research and optimization is of course ongoing.

Wouldn't it be better to prevent micropollutants from entering the environment in the first place?

The removal of micropollutants from wastewater is an important measure for preventing these substances from entering waterbodies. Some substances which end up in surface waters after wastewater treatment cannot be reduced by restrictions on consumption or other measures (e.g. medicines). However, several Eawag research projects have shown that, in parallel, it is also necessary to avoid inputs of micropollutants at source. For example, user guidelines, site-adapted agriculture and effective training of farmers can go a long way towards reducing runoff of pesticides from fields. Equally, modified formulations of additives used in construction materials can reduce the amount leached out by rainwater. In the case of root protection agents applied to bitumen sheets, collaboration between Eawag and manufacturers led to a reduction of more than 90% in the leaching of herbicides. Where environmental releases of toxic substances cannot be prevented, prohibitions on certain highly potent substances should not be ruled out altogether.

Links

- www.eawag.ch > Research > Chemicals and Effects
- http://www.wave21.eawag.ch > Work packages > Micropollutants
- www.oekotoxzentrum.ch > Projekte (German/French)
- Federal Office for the Environment (FOEN) information on micropollutants and the "MicroPoll strategy" project: http://www.bafu.admin.ch/gewaesserschutz/03716/index.html?lang=en
- Zurich Cantonal Office for Waste, Water, Energy and Air (AWEL) documentation on micropollutants (German): http://www.wasser.zh.ch/internet/bd/awel/wa/de/mikroverunr.html
- Swiss National Research Programme 50 (NRP50) on endocrine disruptors: http://www.nrp50.ch

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