TAB OFFICE OF TECHNOLOGY ASSESSMENT AT THE GERMAN BUNDESTAG

Pharmaceutical residues in drinking water and water bodies

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Summary

- The consumption of medicines is increasing. Most of the pharmaceutical substances taken by humans and animals are excreted and can be found in many water bodies and partly even in groundwater.
- Currently, based on existing studies, an acute or chronic health risk from pharmaceutical substances in drinking water can be excluded. However, there are strong indications that pharmaceutical residues in combination with other micropollutants affect aquatic communities. Overall, there are still gaps of knowledge with regard to the occurrence and effects of pharmaceutical residues in the environment.
- With a series of measures, it is possible to reduce the discharge of pharmaceutical substances into the aquatic environment – without compromising health protection. Here, a combination of different measures seems to make sense. In this context, there is an intense debate focusing on the upgrading of large sewage treatment plants with a fourth treatment stage.
- It is necessary to consider which tangible measures should be taken within the framework of a comprehensive micropollutant strategy that is to be pursued.

What is involved

Most medicines administered to humans or animals do not remain in the body, but are excreted unchanged or in the form of metabolites. Ultimately, they reach rivers and lakes via various routes and, in some cases, even end up in groundwater. The question arises as to whether these micropollutants pose a danger to humans and the environment and to what extent there is a need for action.

With regard to the extent and trends of micropollutants in water bodies, groundwater and drinking water, the data situation is unsatisfactory, as there is no comprehensive and systematic monitoring of micropollutants in groundwaters and surface waters in Germany to date. However, sampling and estimates indicate an increase in micropollutants. These observations are confirmed by the growing total consumption of human medicines. Between 2002 and 2012, consumption increased by 30 % to 8,120 t per year. For veterinary medicines, it is not possible to accurately estimate the total quantities consumed, as only antibiotics and some other selected active pharmaceutical ingredients are subject to official registration. After all, the consumption of antibiotics in the veterinary sector has halved from 1,706 t (2011) to 805 t (2015), partly due to legal measures. Since the degradation processes in the environment take a lot of time and the consumption of human and veterinary medicines will probably continue to rise, the occurrence and concentration of pharmaceutical substances and their degradation products in the environment will presumably continue to increase as well.

Residues of human medicines in concentrations of up to 10 µg/l, sometimes even significantly higher, were found in water bodies and particularly in effluents from sewage treatment plants. Residues of veterinary medicines, however, could only be detected sporadically in waters. In the raw water of waterworks, the concentration of pharmaceutical residues is generally very low or even below the limit of detection. However, in some regions – such as the Hessian Ried and parts of Berlin – limit values were exceeded.

Pharmaceutical substances are typically characterised by the fact that they are physiologically effective even in low concentrations. In this context, however, there are currently no indications that the consumption of drinking water is harmful to human health. Nor are the pharmaceutical residues in surface waters directly dangerous to humans in the concentrations currently measured. Though, it is unclear whether residues of antibiotics in the aquatic environment contribute to the development and spread of antibiotic resistance.

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Findings of antibiotic-resistant germs in bathing waters and the underflows of sewage treatment plants have fuelled such fears. In this context, there are still large gaps of knowledge and a substantial need for research.

In contrast to humans, fish and other aquatic organisms are directly exposed to pharmaceutical residues in waters. Laboratory tests and first field observations show that some residues pollute the environment. The most problematic substances are those that have an effect on the endocrine system of organisms.

In view of the more frequent occurrence and the increasing concentration of pharmaceutical residues in water bodies and groundwater as well as with regard to the indications of negative environmental impacts and – at the same time – large gaps of knowledge, the question arises from a precautionary perspective as to which measures should be taken.

Fig. 1 Sewage treatment plant with fourth treatment stage

Image: BR-Studio Franken/Michael Reiner

Measures at the source or at the end of pipe?

Residues from human medicines are discharged with the waste water into the sewage system. The sewage channels act like a kind of funnel and bundle the waste water streams. With the currently used purification technologies, pharmaceutical residues are only partially retained in sewage treatment plants. In municipal sewage treatment plants, however, an elaborate fourth treatment stage can eliminate about 80 % of a large number of different micropollutants – not only pharmaceutical substances. Thus, the fourth treatment stage is an exception to the rule that measures at the source are superior to so-called end-of-pipe technologies. Conversely, however, this does not mean that a limitation to the use of the fourth treatment stage is sufficient. This is due to the fact that it is impossible to eliminate pollutants completely and unwanted secondary substances can be produced. Moreover, the entry paths for veterinary medicines are not recorded.

Residues of veterinary medicines typically take a different route than residues of human medicines. They are spread on meadows and fields with liquid manure and dung from stables. In case of pasture grazing, they also reach meadows. From there, they get into the soil and seep into groundwater,

Antibiotic resistance

- Antibiotics are medicines against bacterial infections. However, bacteria can become resistant to antibiotics. Thus, antibiotics lose their effectiveness. Antibiotic resistance is a serious threat to public health. It is estimated that about 700,000 people worldwide die each year from an infectious disease, because germs are resistant to the antibiotics available.
- Bacteria multiply quickly and, in doing so, change their genetic material. If an antibiotic is insufficiently dosed so that it does not completely prevent the bacteria from multiplying, it exerts a selection pressure on the bacteria, which favours the development of resistant germs. Antibiotic resistance can therefore develop where antibiotics occur in increased concentrations, e. g. in hospitals or animal stables.
- Although water bodies in Germany are certainly not the main source of antibiotic resistance, the detection of multi-resistant germs in streams, rivers and bathing lakes in Lower Saxony in February 2018 was surprising and raised concern. The concentrations of antibiotics in German waters are actually too low to exert a significant selection pressure on bacteria. This is why it currently remains unclear where the resistances have developed and how they have spread. There is a considerable need for research with regard to this issue.

or they are washed into surface waters when it rains. The different environmental compartments are interconnected by the water cycle.

What can be done concretely?

In accordance with the various sources and entry paths, there are basically three areas in which measures to reduce micropollution of groundwater and surface waters by pharmaceutical substances can be applied (fig. 2).

In the health sector, the need for medicines could be slightly reduced – for example as a side effect of general health promotion and preventive measures – as suggested by a pilot study in Baden-Württemberg. It is also proposed that the development of new medicines should not only focus on the therapeutic effect, but also on minimising undesirable environmental impacts. Raising the awareness of doctors and patients with regard to the problem of pharmaceutical residues can also have an impact on the consumption of medicines. Another area is the disposal of old and residual medicines. Although environmentally friendly and safe disposal methods already exist, they are not sufficiently used – because they are often unknown. Wide-ranging information campaigns could help to ensure that old and residual medicines are no longer improperly disposed of via the sewage system.

Fig. 2 Entry paths of pharmaceutical residues in water bodies and potential approaches for countermeasures

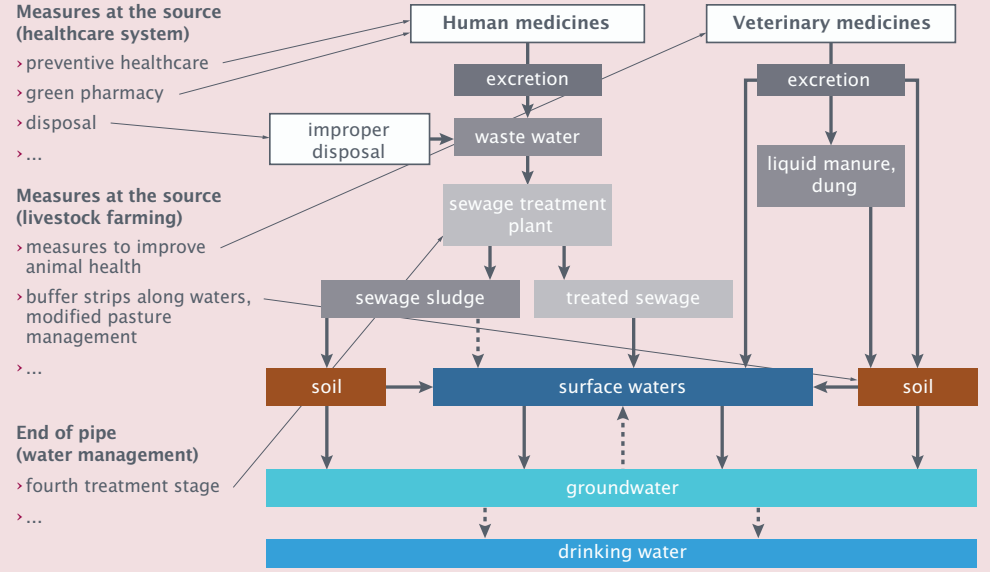

Illustration by TAB based on Ebert et al. 2014

With regard to livestock farming, there are also possibilities to reduce the consumption of medicines without endangering animal welfare. Examples are education and training measures for farmers and veterinarians on preventive measures to improve animal health and thus reduce the consumption of medicines. The way in which the so-called farm manure – i. e. liquid manure and dung – is stored, processed and spread on fields influences the degradation and bioavailability of pharmaceutical residues. Moreover, buffer strips along waters in fields or improved land management of pasture farms could reduce the input of farm manure and thus also pharmaceutical residues into waters.

In the field of water management, the fourth treatment stage of municipal sewage treatment plants is certainly the most important, but not the only possible measure. In addition, it would be imaginable to reduce the discharge of residues from pharmaceutical production into waters e. g. by changing production processes or better purifying waste water from the facilities in industrial waste water treatment plants with further elimination of trace substances. Here, not only activated carbon and ozonation can be used – as it is done in the fourth treatment stages of municipal sewage treatment plants. Depending on the load situation, e. g. membrane filtration systems and UV irradiation can be used as well. It might also be useful to separately collect waste water from hospitals contaminated with specific, poorly degradable substances such as e. g. X-ray contrast media.

Apart from the harmful effect of the inputs, the proportionality of tangible measures to reduce pharmaceutical substances strongly depends on the level of knowledge regarding the unintended side effects of human and veterinary medicines as well as on the confidence in this knowledge. Besides measures that directly reduce the discharge of pharmaceutical residues into the environment, improving the base of information and closing the gaps of knowledge are therefore important elements for better evaluating in the future which measures should be taken and how much effort should be made to reduce micropollutants. This includes a broader monitoring of micropollutants and their environmental impacts, research into the environmental compatibility of active pharmaceutical ingredients, but also a systematic monitoring of side effects in the environment – the so-called ecopharmacovigilance (EPV). In particular, it would make sense to complement the existing pharmacovigilance system for human medicines – which records the

medical side effects at a central point – with a comprehensive environmental information system.

Wanted: a reasonable overall strategy

Increasing consumption of medicines, ever higher concentrations of pharmaceutical residues in water as well as more and more indications with regard to harmful effects are arguments for not only collecting more intensively and systematically information on residues and their effects, but also taking reduction and prevention measures in due time. A meaningful strategy will certainly consist of a smart combination of different measures and should not be reduced to the question of the extent to which municipal sewage treatment plants should be complemented with a fourth treatment stage. The aim must be to reduce the inputs of pharmaceutical residues from different sources, but at the same time to improve the base of knowledge, strengthen the ›polluter pays‹ principle and promote acceptance.

The development of a reasonable overall strategy for dealing with pharmaceutical residues in water is essentially a political task that must ultimately be tackled within the framework of a democratic decision-making process. The following general information should be taken into consideration:

- **Integration into a micropollutant strategy**: A strategy against pharmaceutical residues should be embedded in a more comprehensive micropollutant strategy, i. a. because pharmaceutical residues are only one class among many micropollutants and, in particular, because upgrading municipal sewage treatment plants with a fourth treatment stage is an important option that proves to be effective against a wide range of micropollutants.
- **Implementation and participation**: Besides the EU, the German Federal Government sets the essential legal and administrative framework conditions, in particular with regard to water law and pharmaceutical law. In 2016, the Federal Environment Ministry (BMU) for the initiated a multi-annual stakeholder dialogue on a »Trace Substance Strategy of the Federal Government«. It is to be hoped that this dialogue will provide impetus which will be taken up by the various political stakeholders, translated into legal regulations and accompanied by appropriate administrative measures. Moreover, a broad acceptance by and active participation of as many stakeholders as possible is an important prerequisite for the success of a strategy concerning pharmaceutical residues and micropollutants. It addresses companies, associations, health insurance companies, veterinarians, farmers and consumers.
- **Financing**: The implementation of a strategy against pharmaceutical residues and other micropollutants in the water involves significant costs. There are already cost estimates as well as tangible financing proposals for the important measure of a fourth treatment stage. For many of the other measures discussed, however, there are not even any rough cost estimates available. In this respect, it is currently not possible to provide reasonably reliable projections of the total costs regarding the different combinations of measures. The example of Switzerland, where the fourth treatment stage has recently become mandatory for large plants and polluted waters, shows that costly measures can also be financed if there is a political will to implement them. For the refinancing of measures, e. g. general budgetary resources, fees, an increase or improved efficiency of the waste water charge or other charges can be considered.

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www.tab-beim-bundestag.de/en/research/u10800.html

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