Scientists to combat antibiotic-resistant bacteria in wastewater

In Germany, around 1,500 tonnes of antibiotics per year are administered to humans and animals. As a result, more and more bacteria are developing resistance to common antibiotics, which can make the treatment of bacterial infections very difficult. As part of HyReKA, a cooperative project funded by the BMBF, scientists led by Professor Thomas Schwartz from the KIT are investigating how antibiotic-resistant pathogens spread and how they can be prevented from doing so.

Prof. Dr. Thomas Schwartz

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Prior to the discovery of antibiotics around 90 years ago, people with bacterial infections depended on the effectiveness of their own immune systems to get rid of the infection. This might become the case again in the future as the number of effective antibiotics decreases. This sounds very pessimistic, but many scientists and the World Health Organization have been concerned about this for years. The warnings are becoming more and more urgent: infections with multidrug-resistant bacteria, which have developed resistance to several antibiotics, including common ones, are difficult to treat. At the same time, the number of newly approved antibiotics is decreasing. Around 700,000 patients worldwide die every year from infections with antibiotic-resistant bacteria. "Some projections state that by 2050 more people will die from such infections than from cancer or diabetes," says Prof. Dr. Thomas Schwartz, head of the Department of Microbiology at the Karlsruhe Institute of Technology (KIT).

Multidrug-resistant pathogens are particularly common in hospitals. However, these pathogens are increasingly also being detected in people who have not been hospitalized. It is therefore reasonable to assume that multidrug-resistant pathogens end up in the environment from where they travel back to humans. Against this background, scientists in the research consortium HyReKA, which is being funded by the German Federal Ministry of Education and Research with approximately 7.4 million euros up until the end of 2019, are investigating how antibiotic-resistant bacteria spread through the wastewater, how they behave in the environment and how their entry into the environment can be prevented.

Wastewater treatment plants as major hotspots

Antibiotic-resistant bacteria are now also found in lakes and rivers.

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The researchers have sampled 18 wastewater treatment plants throughout Germany. An important outcome of the project is that wastewater treatment plants are a hotspot for resistant bacteria. "They accumulate there and are released into the environment," explains Schwartz, "because the wastewater treatment processes currently used in Germany are not designed to eliminate unwanted bacteria and antibiotic resistance genes." Resistant bacteria have already been detected in lakes, streams and soils, from where they can find their way back to, and infect, humans.

“People who come into contact with contaminated surface water can become infected with such bacteria,” said Schwartz. “This is not a problem in healthy people, but the bacteria can lead to diseases in the elderly or people with weakened immune systems that are extremely difficult to treat.”

How evolution works

The studies also show that wastewater from hospitals and animal fattening farms, for example, is heavily contaminated. Antibiotic-resistant pathogens as well as large amounts of antibiotic residues end up in the wastewater. However, even in low concentrations, antibiotic residues can exert a selection pressure on bacteria. In other words, those bacteria which have a mutation or have taken up resistance genes allowing them to survive will live on and reproduce as the antibiotic is unable to destroy them.

"To make matters worse, bacteria can transfer their acquired resistance and exchange it with other bacteria, even across

species barriers," says Schwartz. Thus, the more antibiotics enter the environment, the higher the likelihood of other bacterial species to become resistant to antibiotics and spread.

Solution: ultrafiltration

The team led by Thomas Schwartz and other HyReKA partners are therefore calling for municipal wastewater treatment plants, which are collection basins for different effluents, to be equipped with suitable technologies for reducing/eliminating antibiotic-resistant bacteria. "Wastewater treatment plants are a direct link to the aquatic environment and therefore also to humans," says Schwartz. This is why they should be equipped with an additional clarification stage in the future. "Neu-Ulm already has a large wastewater treatment plant, which filters the wastewater through a particularly fine-pored membrane. Results have been very good, and a large proportion of resistant bacteria is retained or even eliminated and no longer enters the environment," says Schwartz.

An ultrafiltration system equipped with extremely fine membranes removes antibiotic-resistant bacteria from wastewater.

Ozonation, which involves the use of ozone for the treatment of water, but also triggers oxidation processes in bacteria, is another possible way of eliminating bacteria. Although ozonation is not as effective as ultrafiltration, it still has its advantages: “Oxidative treatment alters the structures of antibiotic molecules, which, because they are small in size, pass through the membrane. "The use of such processes in municipal wastewater treatment plants would significantly reduce the spread of antibiotic resistance," says the microbiologist.

The decentralized treatment of wastewater, for example in hospitals, is another potential – and sensible – method for relieving the pressure on municipal wastewater treatment plants. “The treatment of wastewater in animal fattening farms, which use large amounts of antibiotics, especially in Germany, would also be an important contribution to protecting against resistant bacteria," said Schwartz, who is also calling for thresholds and monitoring and criticises the slow implementation of the measures: "The data situation is clear, the technology is available, now the authorities have to take action."

The technical upgrade could be funded by raising wastewater charges: "The operators recognize the need, and surveys have shown that the public would be willing to contribute," said Schwartz who estimates that the technical upgrade would cost around 20 euros per capita per year.

Further steps to combat resistant bacteria

However, further steps are needed to curb antibiotic resistance permanently. The amount of liquid manure spread onto fields needs to be controlled. Like wastewater, liquid manure contains antibiotic-resistant bacteria and antibiotic residues, but is also not yet specifically treated to reduce this load. “The use of liquid manure for fertilizing fields leads to a change in soil microbiology, resulting in the accumulation of resistant bacteria. This leads to the infestation of crops with bacteria, and the bacteria are then returned to humans through food,” explains Schwartz.

In addition, the introduction of antibiotics into wastewater needs to be reduced: "This is difficult to achieve in hospitals. In addition, the public still has to be made aware that antibiotics are ineffective for treating common colds. And above all, the use of antibiotics in animal fattening needs to be sensibly controlled. For example, colistin, which is a reserve antibiotic for treating humans, is used in chicken breeding where it is added to the water that chickens drink. This is extremely critical because resistances to colistin have already emerged in the environment,” said Schwarz.

Last but not least, the pharmaceutical industry needs to be encouraged to invest in antibiotics research: as the rapid development of bacterial resistances reduces profit, antibiotics research is on the decline.

HyReKA

HyReKA stands for "Biological or hygienic-medical relevance and control of antibiotic-resistant pathogens in clinical, agricultural and municipal wastewater and their importance in raw waters". The research network is striving to make an active contribution to public environmental health protection. Its goals include investigating the introduction of antibiotic-resistant bacteria and antibiotic residues into the environment, assessing their distribution pathways, risk potentials and transmission risks, developing technical wastewater treatment processes in wastewater treatment plants and formulating recommended actions. The consortium is composed of researchers from various disciplines such as medicine, biology, geography, engineering, agricultural science, food technology and nutrition science as well as partners from municipal water companies and industry.

Besides the KIT, HyReKA involves scientists from the University Hospital in Bonn, the University of Bonn, Dresden Technical

University, RWTH Aachen, the Federal Environmental Agency (UBA), Technologiezentrum Wasser in Karlsruhe (TZW) and municipal partners such as Erftverband Bergheim, Oldenburg-Ostfriesischer Wasserverband (OOWV), Zweckverband Klärwerk Steinhäule and the industrial partner XYLEM Services GmbH.

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