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The Center for Advanced Water Research (CAWR) is a research cooperation between the Helmholtz Center for Environmental Research - UFZ in Leipzig and the Technische Universität Dresden (TUD) in the water research sector

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1. **How can we detect whether our drinking water is polluted and what is the most efficient way to treat polluted water?**

In Germany, as in most other industrialized countries, the quality of the drinking water is very well controlled, especially for chemical and microbiological contamination. Waterworks personnel use indicator parameters for routine monitoring on a daily basis. Periodically, targeted analyses are carried out in specialized laboratories for specific pollutants with high-tech equipment, such as Liquid Chromatography / Mass Spectrometry. Microbiological tests for specific pathogens are required when microbial indicator parameters are exceeded.

For decades, water quality deterioration that could cause acute toxicity or illness has almost never been found in German drinking water. However, drinking water is consumed in high quantities on a daily basis, bringing up the question of long-term effects by contaminant concentrations below the legal limits. Anthropogenic pollution nowadays affects every environmental compartment and of course the natural water cycle, including drinking water resources such as ground and surface water. Substances of emerging concern, e.g. pharmaceuticals, chemicals from personal care products, endocrine disruptors and nano-plastics are brought into the water cycle by urban drainage and industrial activities. These substances are very diverse and some of them are highly resistant against environmental breakdown. In a realistic framework, it is not possible to completely remove all of these contaminants by state-of-the-art wastewater treatment processes. To date, the long-term effects of many micropollutants on human health and the environment are not fully understood; especially the potential effects of pharmaceuticals in our drinking water. A relevant example, which is also one of the priorities of our work at CAWR, is the build-up of antibiotic resistance in environmental microbes caused by background antibiotic concentrations.

Therefore, a public and political debate is currently being held in Germany and Europe on measures to further remove micropollutants in conventional wastewater treatment plants by introducing the so-called “fourth treatment stage,” an advanced purification step that could consist of adsorptive (e.g. activated carbon) and/or oxidative (e.g. ozonation) technologies. In addition to these measures, a reduction of micropollutant inputs is called for through adapted prescription practices, the reduced application of pesticides and veterinary drugs in agriculture as well as advanced processes in the chemical industry. The most efficient way to avoid adverse effects of water pollution for humans and the environment is not the costly removal of micropollutants, but the prevention of their entry into the water cycle.

2. What is sustainable urban water management and how do the challenges differ between rural areas and cities?

Sustainable urban water resources management (UWRM) is one of the central concepts pursued by CAWR researchers. It involves the connection of urban water management with the quantitative and qualitative dynamics of water bodies used for water supply and wastewater disposal, and the analysis of their interaction. In other words, providing long-term water security for human use while at the same time minimizing the human footprint in the aquatic ecosystems and the environment. To achieve this ambitious goal, we have to understand the interconnected network of water resources (supply side), water withdrawals (demand side), the discharge of used water, and the changes of water quality and quantity caused by human activity and use. Also, we need to develop new approaches and solutions for efficient urban water management.

In urban areas, the pressure on aquatic ecosystems is usually high due to large scale and sometimes irreversible anthropogenic modifications of streams and water bodies, and high contaminant emissions originating from urban drainage. Water bodies in urban agglomerations such as the Ruhr area are archetypes of heavily modified water systems. Concerted efforts of involved stakeholders are required in order to restore and/or maintain a sufficient chemical and ecological quality of these water bodies. The Emscher river system, which served as a wastewater drainage system for many decades, has been rehabilitated at a cost of 4.5 billion euros. This project highlights the effort needed to implement a more sustainable urban water management of degraded river catchments in industrialized regions.

A great challenge for water management in rural areas is the diffuse pollution of ground and surface water, mostly stemming from agricultural activities (pesticides, nitrate and phosphate). In 2016, the European Commission initiated an infringement procedure against Germany due to the insufficient implementation of the EU Nitrates Directive, obliging member states to reduce nitrate input into water bodies. Another challenge for rural water management is the comparably low efficiency and high cost of centralized water infrastructure, aggravated by demographic change and rural depopulation. These trends must be included in the future planning of water supply and sanitation for rural areas, incorporating decentralized or semi-centralized solutions.

3. How has Germany successfully implemented solutions for integrated water resource management? What needs to be improved?

According to the definition of Global Water Partnership, Integrated Water Resources Management (IWRM) is a process that promotes the coordinated development and management of water, land and related resources, in order to maximize the resulting social and economic welfare in an equitable manner without compromising the sustainability of vital ecosystems. IWRM addresses water resources management at the catchment level. River basins, for the most part, do not coincide with administrative units, making it difficult to implement integrated concepts. Furthermore, it remains a challenge to include all relevant parties in management concepts, such as the agricultural and industrial sector.

An example of IWRM implementation in Germany and Europe is the collaboration within the framework of the national river basin associations and international river basin commissions, which exist for all large catchments. They have been established in order to overcome administrative constraints in tackling water management on the river basin level. For example, the integrated management of the Rhine River led to a considerably improved ecological and chemical quality today compared to the end of the 20th century. Its water can again be used for drinking water production, and salmon can travel upstream to spawn.

Germany, as an EU member state, currently works on the implementation of the EU Water Framework Directive (WFD). Its objectives are the good ecological and chemical status, in terms of quality and quantity, of all surface and groundwater bodies by 2027. The Water Framework Directive is one of the few legally binding implementations of IWRM worldwide, with a management approach consisting of cycles of evaluation of environmental state, risk assessment, planning and implementation of measures, and monitoring of success. Currently, implementation is underway but 90% of the rivers and 70% of the lakes have not met the objectives for a good ecological status in 2016. The most important reasons were an inadequate hydromorphology, including ecological river continuity, as well as nutrient loads and insufficient oxygen concentrations. Also, the chemical status of most surface water bodies is still not good, due to ubiquitous anthropogenic contaminants such as Polycyclic Aromatic Hydrocarbons, tributyltin and quicksilver, but also other heavy metals, pesticides, and industrial chemicals. Further substantial investments are called for to achieve the goals of the WFD in Germany, especially in the following areas: hydromorphology, agricultural impacts, and urban water management (e.g. upgrade of wastewater treatment plants).

4. Describe one or two current international research projects that the Center for Advanced Water Research (CAWR) is currently carrying out.

One of the current key projects of CAWR is “Managing Water for Urban Catchments”, funded by the Federal Ministry of Education and Research. Within the project, our scientists develop sanitary and environmental engineering system solutions for sustainable water quality improvement in the city of Chaohu and in Lake Chao – one of the five large freshwater lakes in China. Especially during the summer, the discharge of wastewater and diffuse inputs from agriculture result in a massive increase of blue-green algae, with negative impacts on the drinking water supply. Within the project, the aforementioned UWRM approach is implemented, integrating efficient sanitation in urban and rural areas as well as the needs and dynamics of natural aquatic ecosystems. One of the goals of “Urban Catchments” is the development of a drinking water early warning system, which consists of a water quality monitoring network connected to a modelling platform. The project is an important milestone for the development of the Sino-German cooperation in the water sector.