Availability of potable water is endangered due to increased water demand and release of various contaminants, especially emerging ones, such as pharmaceuticals. Therefore, wastewater reuse becomes an important issue. Effective wastewater treatment, including removal of n pharmaceuticals is of major concern, because they are widespread and persistent in environment. For instance, it is estimated that up to 90% of pharmaceuticals pass through human body and end in the wastewater stream. On the other hand, conventional wastewater treatment processes often do not secure reliable removal effectiveness of commonly used pharmaceuticals from wastewater, which may put into question feasibility of wastewater reuse. Additionally, to reduce carbon footprint, such wastewater treatment and reuse must be cost-effective and should not put additional stress on environment. This is the place where porous media filters constructed from environment-friendly filtration media can help. Such filters can be applied in constructed wetlands, where wastewater passes through a substrate inhabited by carefully chosen plant species and in soil-aquifer treatment systems, where wastewater is allowed to infiltrate from the ground surface towards groundwater reservoir (aquifer) through a layer of soil. Contaminant removal in such systems relies on a unique combination of physical, chemical and microbial processes, including sorption, plant uptake, and microbially mediated contaminant transformations. Performance of the treatment depends strongly on filtration media properties, such as hydraulic conductivity, sorption and support for biofilm growth.

In line with the circular economy paradigm, reuse of waste biomass such as sunflower, buckwheat or oats husks in the form of biochar becomes increasingly popular. Biochars are the result of pyrolysis, i.e. heating of waste biomass in conditions of low oxygen availability. Some types of biochar are characterized by good sorption properties and support microorganisms and plant development.

In this project we will investigate how biochars can be used to improve the ability of constructed wetlands and soil aquifer treatment systems to remove from water different forms of nitrogen (a common water contaminant) as well as two popular pharmaceuticals, painkillers available without prescription: ibuprofen and tramadol, which are often detected in wastewater.

Given the multitude of waste biomass that can be used to form biochar we plan in the first phase experiments in laboratory conditions to select the materials most suitable for contaminant removal. Then we will proceed to experiments in mesocosms (columns filled with biochar, soil and plants, exposed to natural conditions) in order to investigate the contribution of biotic (microorganisms and plants) and abiotic (sorption, filtration) mechanisms in removal of nitrogen and pharmaceuticals. Finally, an experimental evaluation of full-scale biochar-amended treatment system will be carried out for at least 18 months.

In parallel to experiments, computer modeling techniques will be used to gain additional insights into contaminant transport and removal processes in biochar augmented treatment systems. We will collaborate with scientists from Belgium, Austria and USA to develop new, more accurate computer models which in future can help to design treatment systems. Our project addresses the UN Sustainable Development Goals: SDG6 Clean water and sanitation, SDG11 Sustainable cities and communities, SDG12 Responsible production and consumption, SDG13 Climate action, and SDG15 Life on land.