Description of the project for the general public

The presence of pharmaceuticals in the environment has become a global problem. The main sources of pollution are pharmaceutical industry, hospitals, households and agricultural farms. An easy access to pharmaceuticals attributes to the increase of their consumption and, as a result, to the increase of their amount in the environment. In 2017 the value of Polish pharmaceutical market reached over 31 billion Polish zloty, from which over 10 billion was due to the sale of medicines and products available without prescription (33%). The statistics show that still numerous people throw away the expired drugs to the garbage or flush them in toilets instead of disposing in pharmacies. Moreover, taking into account that usually pharmaceuticals are not completely eliminated in human body and are often excreted unchanged or as soluble in water metabolites, one can easily imagine how large loading of these contaminants goes to wastewater treatment plants. Unfortunately, the conventional methods of treatment of water and wastewater are not efficient enough in removal of most of pharmaceutical substances. As a result, the pharmaceuticals and their metabolites which are not removed during treatment step, are released into surface waters. That leads to a more and more common presence of these contaminants in rivers, lakes, seas, or even in drinking water. The concentration of pharmaceuticals in natural waters can be as high as a few dozens of $\mu g/dm^3$. These substances constitute a danger both to aquatic organisms and human beings. For example, the presence of antibiotics in the environment promotes the growth of antibiotic-resistant bacteria, leading to decrease of efficiency of these drugs.

Taking the above into consideration, there is an urgent need to develop new, efficient methods of pharmaceuticals removal from water and wastewater. An attractive solution is a hybrid system coupling photocatalysis, being one of Advanced Oxidation Processes (AOPs), and membrane separation. Such systems are called Photocatalytic Membrane Reactors (PMRs). Due to application of photocatalysis, it is possible to degrade the contaminants into CO_2, H_2O and mineral salts, while a membrane serves as a selective barrier for photocatalyst particles and, in some cases, for contaminants present in water and wastewater. To realize the process, it is necessary to activate the photocatalyst with radiation of sufficient energy. The most common solution is application of artificial UV radiation sources; however, numerous laboratories realize intensive research on development of photocatalysts with high activity under visible or solar light. Amongst advantages of PMRs, the following should be mentioned: (i) retention of a photocatalyst in reaction environment and possibility of its recovery, (ii) control of residence time of contaminants in the reactor, (iii) possibility of selective separation of products, and (iv) realization of continuous process with simultaneous separation of products from the reactants mixture.

The aim of the project is evaluation of the influence of process parameters, including the type of applied irradiation (UV or solar) on (i) the efficiency of removal of pharmaceuticals from water of various salinity, as well as from wastewater, and (ii) the resistance of membranes against conditions prevailing in two various PMRs equipped with submerged membranes. In the first PMR the pressure-driven micro-/ultrafiltration (MF/UF) processes will be applied, in which the separation of components of feed solution is based on the sieve effect, while in the second one – membrane distillation (MD) will be utilized, during which the volatile substances are permeating through the membrane due to the partial pressure difference. In both types of PMRs a developed during the project TiO_2-based photocatalyst, active under solar light, will be applied.

The realization of the project will contribute to better understanding of processes taking place in PMRs, in relation to both removal of contaminants (pharmaceuticals) and durability of membranes. The investigations on hybrid systems coupling AOPs such as photocatalysis, and membrane separation techniques are important in terms of development of new, efficient technologies of water and wastewater treatment. Their implementation in full scale will contribute to improvement of peoples' health and standard of living, as well as will have a positive effect on the environment.