POPULAR SCIENTIFIC PROJECT SUMMARY

In the face of growing threats to the natural environment, primarily caused by human activities, there is an increasingly urgent need to develop effective water purification methods. Recent ecological disasters, such as the discovery of over 100 tons of dead fish in the Odra River in Poland, serve as evidence of the ongoing problem. Additionally, the COVID-19 pandemic, declared by the World Health Organization in 2020, posed a significant threat to the aquatic environment due to the global increase in waste production, especially pharmaceuticals, which quickly made their way into municipal sewage treatment plants. However, current water purification techniques, such as adsorption and coagulation, fail to solve this problem, merely transferring contaminants to another phase. Other conventional processes, such as sedimentation, filtration, and membrane technologies, generate significant operational costs. Therefore, there is a growing need for the rapid development of innovative water purification methods. One of the proposed methods is photocatalytic water treatment, which enables the removal of harmful pollutants such as pharmaceuticals and pesticides. However, despite research conducted over the past few decades, the application of photocatalysis in water treatment systems is still very limited. Hence, the urgent development of new technological frameworks that will accelerate the development of photocatalytic water treatment methods by overcoming current limitations becomes crucial.

In response to contemporary expectations, the planned project focuses on three key areas that are fundamental for effective photocatalytic water purification. The first element is the development of a photocatalyst, which is an integral part of the photocatalytic process. Therefore, one of the research assumptions is to create a three-dimensional photocatalytic matrix based on titanium dioxide (IV) using microwave technology. The main goal of this part of the project is to improve the stability and reusability of the photocatalyst, leading to an increase in the efficiency of photocatalytic processes. We assume that this stage of the project, focused on materials science, will be a significant advancement in the approach to photocatalytic water purification, eliminating defined drawbacks associated with the photocatalytic material.

The second area is related to process engineering and is based on the research assumption that the integration of molecular imprinting technology into the production process of photocatalytic matrices will increase their selectivity during the water purification process and ensure long-term stability. This technology allows for the creation of specific sites on the surface of photocatalysts that are selective toward a particular contamination. Thus, it ensures the precise removal of pollutants, minimizing the risk of unintended reactions and enabling more efficient energy use during the process. We believe that the above stage of the project, focused on process engineering, will eliminate the identified drawbacks of photocatalytic water purification, particularly those related to process selectivity.

The collected data will be a key element in achieving the main goal of the project, which is the development of innovative photocatalytic reactors that are essential for the effectiveness of the water purification process. An important stage in the photoreactor design will be the spectral matching of the light source to the produced photocatalytic matrices, allowing for the maximization of energy use and the overall efficiency of photocatalysis. One of the significant elements of the designed photoreactors will be the reduction of the surface loss of the photocatalyst in the unit volume of water, due to the limited access of the photoactive material to the photons generated by the light source. However, the validation of flow intensity will be the critical factor to ensure a compromise between the contact of the photocatalyst with the degraded pollutant and the stability of the photocatalytic matrix itself.

The proposed research is a response to current challenges related to photocatalytic water purification, especially concerning the lack of a holistic approach to this process. The project focuses on three main problems identified in the field of materials science, reactor engineering, and processes. By using sustainable and ecological strategies, our goal is to develop more efficient, precise, and durable solutions in the field of photocatalytic water purification. The research focuses not only on improving the process itself but also on minimizing the negative impact on the environment by reducing energy consumption and generating less waste. We believe that our efforts will contribute to significant progress in the field of environmental protection and water purification, which will benefit aquatic ecosystems and promote sustainable development.