Owing to the increasing environmental pollution, which is majorly caused by anthropogenic activities (man-made processes), the people are now more concerned, around the globe. The increasing number of various types of organic pollutants, including pharmaceuticals, pesticides, dyes, heavy metals, and personal care products are increasingly being detected in our water systems, but unfortunately, most of them are not removed during the present-day wastewater treatment plants. The presence of all these contaminants undesirably compromise the quality of water and shows a serious threat to human beings and aquatic organisms. This issue is inevitably increased because of the lack of efficient technologies for the proper disposal, management, and recycling of waste. It has become meaningful to track alternative technology that is essentially smart, greener, and environmentally competent. Enzyme holds a promising role to mitigate any kinds of contaminating agents in the environment, in a specific, easy to monitor, and highly controllable manner. Enzyme-based processes offer many advantages such as low energy input, non-toxicity, ability to operate under mild aqueous conditions, reduced amount of sludge generation, and can be applied over a wide range of pollutants. In the presented proposal, the main research objectives are to design immobilized peroxidases-based robust bio-catalytic systems using two different immobilizing supports (chitosan-based renewable/sustainable support) as well as novel ‘metal-organic frameworks’ (MOFs), and their exploitation to degrade a diverse set of emerging pollutants. Finally, the ideal processing conditions will be then utilized in an immobilized peroxidases-based bio-catalytic reactor for real-time monitoring and the continuous or semi-continuous enzymatic treatment of ECs and ECs-mediated polluted solutions (water matrices). The proposed research project is interdisciplinary and the obtained data would meaningfully enrich the cutting-edge knowledge in the field of applied biology, material science, biotechnology, process engineering, and environmental protection by providing information on the development of new immobilization supports for peroxidases and mitigation of emerging contaminants.