Executive summary of the activities carried out

during the project implementation period (03.01.2025 – 31.12.2025)

In Stage 1 (2025) of the project **"***New 2D-carbon structures decorated with metal oxides for water decontamination and their impact assessment on plants*" (2DMOx-WAT-DEC), new materials based on 2D carbon structures were prepared and characterized. These structures were obtained from both graphite and various biomasses, such as hemp fibers and apple residues, using microwave irradiation and pyrolysis. The synthesized materials were subsequently functionalized with metal oxides (Fe_3O_4, CuO, MnO_2, MgO) in different mass ratios, using extracts from plant residues (apples and carrots) and *Urtica dioica* L. A total of 20 materials based on 2D carbon structures were obtained, 16 of which were functionalized with metal oxides. Their characterization was performed using Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), Brunauer–Emmett–Teller (BET) analyses, transmission and scanning electron microscopy (TEM, SEM), and energy-dispersive X-ray spectroscopy (EDS).

Preliminary adsorption tests were carried out for selected pollutants (pesticides and pharmaceuticals) in synthetic water to evaluate the performance of the developed materials. The results obtained, so far, indicate that graphene-based materials derived from apple residues show lower adsorption efficiencies than those obtained for graphene-based materials derived from hemp fibers. However, these materials can still serve as promising alternatives for future investigations. To date, graphene obtained from hemp fibers has shown superior performance, with adsorption efficiencies ranging from 81 - 84% for pesticides and 83 - 91% for pharmaceuticals. Functionalization with Fe_3O_4 led to an increase in adsorption efficiency (up to 95.65 %)and provided the materials with magnetic properties useful for rapid post-adsorption separation. Materials modified with CuO exhibited lower adsorption efficiencies, while materials functionalized with combinations of metal oxides showed variable behavior: some were more suitable for pesticide adsorption, whereas efficiencies for pharmaceuticals were generally lower. These results highlight the significant influence of the order in which oxides are introduced during the synthesis process, as well as the dependence on the type of pollutant.

The results obtained in this stage underline the importance of the type of graphene and the functionalization approach in determining the selectivity and adsorption efficiency of pollutants in synthetic water. The tests performed are preliminary and form the basis for future stages, which will aim to optimize and establish adsorption mechanisms, as well as evaluate the regeneration capacity of the materials, to develop efficient and sustainable adsorbents for the treatment of contaminated water.