

PUBLISHABLE SUMMARY of the project research work – **2nd Year** (period SEP.2020 – AUG.2021)

The main activities during the reporting period (SEP20-AVG21) took place within the work packages **WP4 and WP3 and WP5** and **additional activities within WP2**.

The work of IOS d.o.o. was aimed at completing the planned activities under the **WP3** work program and intensive implementation of activities planned under the WP4 program. We completed the activities of testing the toxic impact of functionalized stabilized magnetic nanoparticles on the aquatic environment and humans, and completed testing the impact of heavy metals and the impact of functionalized stabilized magnetic nanoparticles on biomass. We have reviewed the latest legislation on water recycling, and, in order to carry out the synthesis and preparation of non-materials, also the latest recommendations on Nanosafety in relation to REACH legislation. Based on an extended review of the literature for heavy metal target ions, we performed desorption under selected conditions and examined the possibility of regeneration of functionalized stabilized magnetic nanoparticles. **Milestone M3** was achieved for the Pb^{2+} ions desorption from the surface of functionalized stabilized magnetic nanoparticles with the possibility of regeneration of nanoparticles in 3 cycles. Despite the completion of the WP3 work program, we are still planning activities to improve the possibility of desorption of CrT ions from the surface of functionalized stabilized magnetic nanoparticles and regeneration of nanomaterials.

Under **WP4**, work focused on transferring the synthesis of the preparation of non-stabilized functionalized magnetic nanoparticles from a laboratory scale to an increased scale-up scale, and performing the first synthesis on an increased scale (scale-up; 20x magnification), with a view to we provided enough material to perform tests under WP2, WP3, WP4 and WP5. Based on several laboratory and scale-up syntheses, a study of the influence of parameters (PrOH, H₂O, NH₄OH, sol-gel precursors) on the surface of magnetic nanoparticles and testing the possibility of replacing chemicals with more environmentally friendly ones was performed. Based on the current characterization of synthesized products with selected methods (FTIR, TEM, BET, TGA), the evaluation of the success of adapting the transfer of laboratory synthesis of functionalized and stabilized magnetic nanoparticles on a scale-up scale was evaluated. For the purpose of testing scale-up functionalized and stabilized magnetic nanoparticles, the repeated scale-up synthesis was repeated several times and the final products were validated, which will continue until the end of the project. With the prepared functionalized stabilized magnetic nanomaterials, we performed extensive adsorption tests from model and vaccinated municipal wastewater, on a series of different heavy metal ions (Pb^{2+} ; CrT; Cd^{2+} ; Co^{2+} ; Cu^{2+} and Fe^{3+}), and additionally in cooperation with the project partner ROTO-GRAD doo for Hg^{2+} ions, and determined the adsorption characteristics of the adsorption magnetic nanomaterial used. Based on the extensive results obtained, activities in the direction of studying kinetic models are planned below. For the purpose of optimizing the material that could alternatively be used in the cartridge system, the preparation of functionalized nanoparticles (with alternative functional groups, eg SH (thiol)) based on silicon dioxide (SiO₂) and magnetite (Fe₃O₄) on a laboratory scale is planned, and continuous characterization and determination of adsorption characteristics of products.

In parallel, activities will be carried out in the direction of improving the coating of alternative materials / carriers by the sol-gel method. As we faced delays in the supply of chemicals and key equipment for the implemented activities during the activities within **WP2 and WP5**, the activities were targeted at the development and production of so-called demonstration membrane biological reactor (DEMO MBR), and PROTOTYPE MBR reactor tank.

DEMO MBR testing is currently ongoing and will continue in the next reporting period in the direction of testing DEMO MBR in connection with the cartridge system, namely model and wastewater containing heavy metal ions, with the aim of defining the final installation of the cartridge to DEMO MBR. In parallel, the LCA process analysis will be performed, as well as the equipping and relocation of the PROTOTYPE MBR to the real environment to the treatment plant, where testing and validation will take place until the end of the **WP6** project.

In cooperation with the project partner, additional research was carried out within **WP2**, which was not planned, but was aimed at optimizing the cartridge system and the development of alternative adsorption material. Various natural materials and functionalized magnetic nanomaterial were combined and compacted into tablets, coated tests with sol-gel coatings of functionalized silicon nanoparticles (SiO₂ NMs) were performed, and the effectiveness of the coating was verified by adsorption tests on selected metal ions.

Additional activities were carried out in the direction of verifying the influence of anions on functionalized magnetic nanomaterial, the influence of a mixture of different ions from model and spiked municipal wastewater and adsorption of Hg²⁺ ions. Despite the achieved **Milestone M2** (ie developed cylindrical cartridge tested for adsorption of Pb²⁺ ions on functionalized scale-up magnetic nanoparticles from model and spiked municipal wastewater) and achieved **Milestone M5** (DEMO MBR in connection with a cylindrical cartridge system).

Cartridge system optimization activities and testing of alternative adsorption materials will continue within **WP5**, where the cartridge system will be tested with nanomaterials connected to the DEMO MBR, in order to define the final installation of the cartridge to the DEMO MBR and prepare a protocol for using the cartridge system and cartridge system in connection with the DEMO MBR. Under **WP7**, due to the increased emphasis on the preparation of the PROTOTYPE MBR marketing plan and the preparation of original scientific articles, there were not many promotional activities. Finally, the project was presented at the EXPO in Dubai, from 1.10 - 8.10.2021. So far, the management activities have been running smoothly, without complications, with more frequent technical meetings, so we do not expect any major problems in the future.